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RESERVE
A Summary of Current Program and
Preliminary Report of Progress //

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3 POULTRY RESEARCH

of the
United States Department of Agriculture
and cooperating agencies

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D & R-PREP.

This progress report on U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

There is included under each problem area in the report, a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research. Also included is a brief description of related work conducted by private organizations. No details on progress of State station or industry research are included except as such work is cooperative with U.S.D.A.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the last two years. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, Agricultural Marketing, and The Farm Index.

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UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.
January 2, 1963

OTHER COMMODITY AND FUNCTIONAL REPORTS

A progress report similar to this one is prepared for use by each of the following research and marketing advisory committees:

Citrus and Subtropical Fruit	Sheep and Wool
Cotton and Cottonseed	Sugar
Dairy	Tobacco
Deciduous Fruit and Tree Nut	Vegetable
Forage, Feed and Seed	Economics
Forestry	Farm Equipment and Structures
Grain	Food and Nutrition
Livestock	Food Distribution
Oilseeds and Peanut	Home Economics
Potato	Soils, Water and Fertilizer
Rice	Transportation and Storage

Two additional reports of progress are prepared in order to make available the complete research program. They are:

Ornamentals and Other Miscellaneous Commodities
Other Research — Cross Commodity

ORGANIZATIONAL UNIT REPORTS

All of the material in the commodity and functional reports listed above is the same as that found in the 20 division and 3 service research reports listed below.

Agricultural Research Service (ARS)

Agricultural Engineering
Animal Disease and Parasite
Animal Husbandry
Crops
Entomology
Soil and Water Conservation
Utilization -- Eastern
Utilization -- Northern
Utilization -- Southern
Utilization -- Western
Human Nutrition
Clothing and Housing
Consumer and Food Economics

Agricultural Marketing Service (AMS)

Market Quality
Transportation & Facilities

Economic Research Service (ERS)

Farm Economics
Marketing Economics
Economic & Statistical Analysis
Foreign Development and Trade Analysis
Foreign Regional Analysis

Other Services

Farmer Cooperative Service (FCS)
Forest Service (FS)
Statistical Reporting Service (SRS)

A copy of this report or any of the others listed above may be requested from Max Hinds, Executive Secretary, Poultry Research and Marketing Advisory Committee, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

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INTRODUCTION

Poultry research as used in this report is concerned with the production, processing, marketing, and consumption of chickens and turkeys and their eggs and meat. Also, some research is done with ducks and geese. The report covers Farm Research, Utilization Research, Marketing Research, Economic Research, and Consumer-use Research of the USDA and cooperating agencies. Only a brief description of the related work of the State Experiment Stations and industry is included.

Under each of the Problem Areas there is a statement describing the program of work underway and the professional man-years devoted to the major kinds of research included. The relative scope of the total research effort pertaining to the poultry industry is indicated by the approximate number of professional man-years employed: 150 by USDA, 300 by the State Experiment Stations and about 600 by industry and other organizations.

A brief report of Progress and significant findings for USDA and cooperative programs is given for each phase of the research program. A considerable amount of basic cross-commodity and functional research that will supply new knowledge applicable to poultry problems is not included in this report. Such research is included in the functional reports such as "Economics," "Soils, Water and Fertilizer", and in the "Other Research" report.

Research by USDA

The farm research dealing with poultry comprises investigations of breeding, physiology, nutrition, viability, diseases, insects, housing, and management. This research is conducted by the following divisions of Agricultural Research Service: Animal Husbandry, Animal Disease and Parasite, Entomology, and Agricultural Engineering. In fiscal year 1962 this work involved 84 professional man-years compared with about 240 at State Experiment Stations and an estimated 430 for industry.

Utilization research deals with the processing phase involving slaughtering the birds and processing the meat and eggs. Also, it is concerned with improved equipment and processes. The work is done at the Western Utilization Research and Development Division, Albany, California, and under contract with State and foreign-country laboratories and in cooperation with the industry and other organizations mentioned under Program for each research area. In fiscal year 1962 the work involved 27 professional man-years compared with about 20 at State Experiment Stations and 70 estimated for industry.

Marketing research involves the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer. The work reported herein is conducted by two divisions in the Agricultural Marketing Service: Market Quality, and Transportation and Facilities. In fiscal year 1962 this work involved 14 professional man-years compared with about 6 at State Experiment Stations and about 150 estimated for industry.

Economic research is concerned with marketing costs, margins and efficiency, market potential, supply and demand, outlook and situation, and improving marketing through research with farmer cooperatives. Fundamental research contributes tools for determining elasticities of demand, statistical formulas, and other analytical guides that can be applied to different situations. The work reported herein is done by the Economic and Statistical Analysis and the Marketing Economics Divisions of the Economic Research Service, and by the Marketing Division of the Farmer Cooperative Service. Approximately 20 professional man-years were devoted to this work in fiscal year 1962 compared with about 30 at State Experiment Stations. Because of the functional nature of this work by industry, a reliable estimate by commodity is not available.

Nutrition and Consumer-use research pertains to composition and nutritive value; physiological availability of nutrients and their effects; and new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions. This work is done by the divisions of Human Nutrition Research and Consumer and Food Economics Research of the Agricultural Research Service. In fiscal year 1962 this work involved approximately 5 professional man-years compared with about 3 at State Experiment Stations. A reliable estimate of work done by industry by commodity is not available.

Research by State Experiment Stations

There is included under each problem area a brief and very general statement on the nature of the research being conducted by the State Agricultural Experiment Stations and the professional manpower being devoted by the State stations to such research.

Consolidating this information for the entire field of interest we find that in fiscal year 1962 a total of 302.7 professional man-years were spent by the State Agricultural Experiment Stations on poultry research. In addition, 92.8 professional man-years were devoted to research in animal biology, many of which were oriented toward poultry.

Poultry research in 1962 was in progress in 51 of the 53 State Agricultural Experiment Stations. Studies underway were carried out by research workers in Departments of Poultry Science, Animal Science, Agricultural Economics, Agricultural Engineering, Agricultural Chemistry, Home Economics, Veterinary Medicine, Food Technology, Genetics and Entomology.

Poultry research at the State Agricultural Experiment Stations in 1962 included 43.3 man-years on breeding, 50.2 man-years on physiology and management, 64.7 man-years on nutrition, 5.3 man-years on improvement of viability, 4.3 man-years on production influences on poultry and eggs, 52.0 man-years on diseases and parasites, 3.3 man-years on poultry insects, 15.6 man-years on equipment and structures, 21.4 man-years on utilization research and development, 6.1 man-years on market quality of poultry products, 30.6 man-years on marketing economics, 1.8 man-years on economic and statistical analysis, 0.8 man-years on farmer cooperatives and 3.3 man-years on human nutrition and consumer research.

No details on progress of State station research are included in this report except as such work is cooperative with USDA.

Research by Industry and Other Organizations

The 600 professional man-years estimated for calendar year 1961 as industry's participation in poultry research are employed primarily by feed and equipment manufacturers, processors of poultry products and chemical companies. Industry activity is greater in poultry nutrition and breeding than for any of the species of farm animals. Only a few of the feed companies are doing basic research. Most work is on new product development of which very little work is ever published. Manufacturers of chemicals and feed are becoming dependent on basic information on nutritive requirements of new high producing layers and broilers that convert a high ratio of feed into product. These developments offer industry an opportunity for testing the new compounds, depending primarily on public agencies for consultation. Most of the identification and classification of insects, diseases and parasites is done by public institutions.

Only limited work is done by industry to overcome its biggest problem of disease control. About 10 professional man-years are devoted to avian tumor research. Most of this is on Rous sarcoma and is done in medical schools or medical research laboratories.

Utilization research by the poultry industry is estimated at 11 percent of the total industry effort devoted largely to control methods, standardization of products, and product quality and formulation. The results of such work are generally kept confidential.

The greater part of the marketing economic research in industry is conducted in connection with new product development and in merchandising and promoting farm products. In addition, industry contributes in a large way to State and Federal research programs by offering its facilities and facts to the public research agencies. Public research is used for comparison and analysis where private research does not have access to the plants and records of competitors. Industry participates heavily in consumer preference research but largely with respect to a firm's own brand name.

Industry is showing an increasing willingness toward cooperative research with public agencies. This is well illustrated in the chemical field where increasing costs, difficulty, and the time required to secure clearance because of residue problems before a new pesticide can be used on food products make it less attractive for the private companies to work alone. Basic research by private companies is now even less attractive than before and makes increasingly evident the necessity for basic research by public agencies. The advantage of cooperative applied research between public and private agencies is well illustrated in the work with stored products insects. Here literally millions of dollars worth of produce, materials, equipment, storage space and additional manpower are made available by industry at no cost to the Department.

It has been estimated that one billion dollars per year is being expended in building new and modernizing old marketing facilities. Planning of marketing facilities that benefit handlers of commodities flowing through the marketing channels is of such magnitude and affects so many individual and community interests that its nature makes it a public activity. A small Federal staff makes an important contribution to overall market planning which is utilized by architectural and engineering firms to develop plans, drawings and specifications for specific facilities on particular sites. In contrast with facility research, industry research in the equipment field is at a man-year ratio of 350 to 1. In this research the emphasis is on new or improved items of equipment which can be patented and for which there is thought to be a ready market outlet.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Avian anatomy. AH scientists engaged in longtime investigations on avian anatomy published in 1961, the "Atlas of Avian Hematology."

This publication has made available to poultrymen, veterinarians, and research workers an important new tool for study and diagnosis of abnormal blood-cell conditions in chickens. Reviews of this work in scientific journals of this and other countries have praised the scientific and journalistic contribution of the work.

Primarily because of his leadership in this study, Dr. A. M. Lucas of the Regional Poultry Research Laboratory recently received the Superior Service Award of the USDA, the Tom Newman Memorial International Award by the Poultry Association of Great Britain, and was selected as the first Honorary Member of the American Association.

Ventilation of livestock buildings. Research in cooperation with State Experiment Stations has obtained much needed basic data on the heat and moisture given off by cattle, hogs, and poultry, and on the influence of building environment on production and feed consumption. The heat and moisture dissipation data are considered basic design data for ventilation systems of poultry, dairy and swine buildings. They appear in design handbooks including the 1962 Guide and Data Book of the American Society of Heating, Refrigeration, Ventilating, and Air Conditioning Engineers, and are used by makers of ventilating equipment, prefabricated buildings and package buildings as well as by specialists advising farmers on their own construction. Building improvements resulting from the above research have contributed to the substantial rise in efficiency of poultry production that has occurred during the past decade.

Major Cause of Egg Spoilage Eliminated. Basic studies of the nature of bacterial growth in egg white have revealed that trace amount of iron counteracts the protective action of the conalbumin, a protein component of egg white, thus permitting spoilage. Applied studies based on this finding show that iron in the water used to wash eggs can be high enough to markedly influence spoilage. With wash water containing 5 to 10 parts per million of iron, a level commonly found in well water, spoilage is two- to four-fold that obtained with water containing less than 0.5 parts per million of iron. This discovery is helping egg producers and processors reduce the serious shell egg spoilage that accounts for a loss of approximately \$20 million annually. Major egg producers are starting to treat egg wash waters to lower iron content to 0.5 per million in order to eliminate excessive spoilage.

Automatic egg grading and packing. A commercial egg grading line adapted to electronic bloodspot detection and incorporating mechanized sizing and packaging was developed. Commercial models of this line now in use in over 150 plants and similar lines employing the same principles have resulted in a net saving of 11 cents per case when compared with conventional manual methods of grading and packing eggs.

Consumer information on poultry obtained. Studies have shown that chickens now reaching the market can be baked at 400° F. and still be as juicy and desirably browned as those baked for a longer time at the lower temperatures formerly recommended.

Similar studies show that turkey is at its best when cooked the shortest possible time for adequate doneness. Small turkeys can be braised at 450° F. in a covered roaster in much less time and with the same quality as turkeys roasted in an open pan at 325° F. However, the appearance of the roasted turkey is better. Roast turkey yields almost 50% edible meat, about the same as chicken but roast duck yields less than 25% cooked meat because of its higher fat content.

Programs of Marketing Service and Education

The Research and Marketing Act of 1946 authorized a number of activities in addition to research. Some of these are: "to conduct and cooperate in consumer education...to collect, tabulate, and disseminate statistics on marketing agricultural products...to develop and promulgate procurement standards and specifications for agricultural products...to inspect, certify, and identify the class, quality, quantity and condition of agricultural products...and to conduct information programs designed to eliminate artificial barriers to free movement of agricultural products."

Part of two programs are included in this report: one, a cooperative service financed with matched funds, carried out by State Departments of Agriculture; the other is a statistical service program to provide statistics on eggs and poultry. Both were selected because they are closely related to research work included in the report.

The value of service, educational and regulatory programs can be observed every day around us. The statistics are used constantly in making business decisions by persons in all segments of the poultry industry from producers to consumers. Inspection, grading and regulatory activities insure a constant supply of wholesome poultry and eggs. Such programs involving cooperative activity contribute greatly to the high standard of living made possible by our agriculture.

I. FARM RESEARCH

POULTRY - BREEDING

Animal Husbandry Research Division, ARS

Problem. Poultry breeders have made greater use of current genetic knowledge than any other group of livestock breeders. So widely have new principles been adopted in the industry that many breeders question whether further progress is being made in improving certain traits. They believe that the useful genetic variation already may have been exhausted. Information is needed as to the relative rates of progress which will result from various breeding systems for improving economic traits such as egg and meat production, respectively. Are different systems required at different stages in the breeding program? Knowledge is required on the heritabilities, genetic correlations and gene-environment interactions, and the consequences of selection on these parameters, in order to design the most efficient breeding systems. Information on the physiological basis for the action of certain genes would lead to a better understanding of controlling heredity for optimum performance. Also, economics of production should be improved through basic knowledge on the genetic aspects of feed utilization efficiency and of various stresses during selection.

USDA PROGRAM AND RELATED PROGRAMS OF
STATE EXPERIMENT STATIONS AND INDUSTRY

This is a continuing long-term program involving basic studies of the inheritance of egg production and broiler characteristics. Much of the research is conducted within the framework of four regional projects. In addition to financial aid to several of the State contributing projects and major contributions to the establishment and maintenance of central facilities, the USDA also provides coordinating personnel located at Athens, Georgia; Lafayette, Indiana; and Beltsville, Maryland. The close working relationship between the USDA and State experiment stations in the four regional projects provides for integrated research on a large scale without duplication of effort. The major emphasis in the North Central region is on egg production traits and the research is done at the Regional Poultry Breeding Laboratory, Lafayette, Indiana, and at 12 cooperating State experiment stations. In the Southern region the major emphasis is on broiler traits and the work is conducted at the Southern Regional Poultry Genetics Laboratory, Athens, Georgia, and at 14 cooperating State experiment stations. The work in the Northeastern region involves the improvement of chickens through genetic and physiological studies and is conducted under cooperative projects at 11 cooperating State experiment stations. Cooperative work on turkeys is carried on with six Western States. Work at Beltsville, Maryland, involves the study of the inheritance of egg

and meat production traits. The work on performance testing and disease control, in connection with the National Poultry and Turkey Improvement Plans is carried on with cooperating Official State Agencies in 47 States.

A Research and Marketing Act contract with Purdue University Agricultural Experiment Station provides for a study of the genetic statistics of inbred poultry lines and their combination in single crosses, four-way crosses, and top-crosses. This two-year study utilizes data accumulated from the North Central Regional Poultry Breeding Project and will be completed in 1963.

During the past 12 months seven USDA line projects were terminated and two new ones were initiated.

A total of 10.2 professional Federal man-years are devoted to this program annually. Of this number 4.6 man-years are devoted to genetics and interrelations of performance traits, 3.0 to performance testing, 1.5 to selection and systems of breeding, and 1.1 to program leadership.

State experiment stations reported a total of 43.3 professional man-years of which 20.2 are included in regional projects and 23.1 are for nonregional research. The 43.3 man-years are divided among the subheadings as follows: genetics and interrelations of performance traits 18.0, performance testing 3.9, selection and systems of breeding 21.4.

Industry and other organizations are very active in the field of poultry breeding. Fairly accurate estimates of the number of professionally trained geneticists or those with the equivalent experience who work for industry and other organizations in poultry breeding are possible. Egg breeders employ approximately 26, broiler breeders 14, and turkey breeders 6, on a full-time basis. In addition, there are other organizations that make some attempt to improve poultry and it is estimated that egg breeders of this type devote the equivalent of 18 professional man-years, broiler breeders 5 professional man-years, and turkey breeders 4 professional man-years. Taken all together it is estimated that 75 man-years of effort go into research by commercial poultry breeders. Almost all of this private research is developmental in nature. Occasionally one or two of the larger organizations have research which is published in scientific journals.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits1. Genetic Aspects of Nutritional Deficiencies.

Selection for fast and slow growth on a methionine deficient diet indicates that lines can be developed that differ significantly in their ability to utilize a diet deficient in one of the essential amino acids. Analysis of variance shows a highly significant difference between lines but no difference at 3 weeks due to sex or sex x line interaction when fed the deficient diet. The lines did not differ when fed a commercial broiler ration from hatching to three weeks of age. Chicks from the F-line were generally about 50% heavier at three weeks of age than the S-line chicks when fed the methionine deficient diet. It was noted that the F-line laid somewhat earlier but when a production peak was reached the rate of lay was almost identical in the two lines. Egg weight was approximately two grams per egg greater in the F- than in the S-line. The two lines did not appear to differ in either fertility or hatchability. There was no consistent difference in mortality between the lines. (AH el-44)

2. Gene-Environment Interactions

Gene-environment interaction studies involving both egg and meat production, were conducted as part of the Southern Regional Poultry Breeding Project. In one instance egg production stock and in the second, meat production stock were hatched in Athens, Georgia. The chicks were shipped to cooperating State experiment stations and all were started on feed at the same time.

Three trials of the meat phase were concluded during the reporting period. Ten stocks were reared at eight locations and 2-, 4-, 6-, and 8-week individual body weight and mortality data were recorded. An analysis of variance based on means indicates highly significant differences (1% level) for all main effects (location, source, sex, and trial) at 2, 4, 6, and 8 weeks. This is also true for all first order interactions except for source x sex, which was nonsignificant at two weeks. All second order interactions were nonsignificant except location x sex x trial at 2 weeks and location x source x trial at 2, 4, 6, and 8 weeks which were significant at the 1% level. Two gene-environment interaction studies involving 10 different egg laying stocks reared at nine cooperating State experiment stations and the Regional Laboratory have been completed. The data are being analyzed but preliminary observations indicate considerable variation in performance with respect to source and location. (AH el-44)

3. Egg Quality Traits.

A study involving egg production and various egg quality traits in White Leghorns was concluded at Beltsville. Results indicate high negative genetic correlations of $-.608$ between egg number and Haugh units and of $-.568$ between egg number and albumen height. (AH el-30 Rev.)

The degree to which albumen quality loss in storage is heritable and its relationships with other economic traits were studied at the North Central Regional Poultry Breeding Laboratory. The heritability of Haugh unit loss between the time of laying and the end of a two week storage period was $.225$ (additive) and $.31$ (nonadditive). The heritability of both Haugh units fresh and stored was $.61$ for additive effects and $.13$ and $.24$, respectively, for nonadditive effects. A genetic correlation of -0.87 between Haugh units loss and the ratio of the stored Haugh unit value to the fresh Haugh unit indicates little difference exists between these two methods for measuring albumen quality loss. Since Haugh units stored was found to be highly correlated with the trait, percent stored of fresh Haugh units, and has a higher heritability and genetic standard deviation, it appears to be the most logical trait to use in selection for better albumen quality at the point of consumption. Egg size and albumen quality were highly and positively correlated due to additive effects, but negatively correlated due to nonadditivity. Genetic correlations between body weight and albumen quality loss were similar to the above. High egg production and early sexual maturity were associated with poorer egg quality. (AH el-43)

4. Genetic Variation in Economic Traits.

An experiment with White Leghorns to increase summer egg production under arid, semitropical conditions at Glendale, Arizona, was completed after seven years of study. Highly significant differences were demonstrated between the preceding 8 months of egg production and the 4 months of summer production, and between years and birds for both of these factors. The phenotypic correlation between the 8-month period and the 4-month summer period was $.52$. The interaction between the preceding production and summer production varied between years and this source of variation was highly significant. Breeding for improved summer production, by selection on the basis of the summer rate of production was successful. (AH el-1, Rev.)

The inheritance of economic traits in the Regional Cornell control population was studied at the North Central Regional Poultry Breeding Laboratory. Heritabilities due to additive effects were 0.26 for age at first egg, 0.62 for 32-week egg weight, 0.62 for 32-week body weight, 0.06 for percent production to January 1, 0.16 for percent production to 72 weeks of age and 0.10 for albumen score in June. Consistently higher estimates of heritabilities from the dams' variance components than the sires' indicated maternal effects for age at first egg,

32-week egg weight, 32-week body weight, percent production to 72 weeks and USDA albumen score. Dominance effects were important for age at first egg, egg weight, body weight, percent production to January 1, percent production to 72 weeks and USDA albumen score. The genetic correlations between egg weight and egg production and between egg production and albumen quality were negative. These results emphasize the complexity of the inheritance of economic traits and help to explain the difficulties which apparently have arisen in maintaining progress in selection programs. (AH el-43)

Virginia workers have noted that breast angle differences between lines have increased in each of three generations of selection for broad and narrow breast angle at 8 weeks of age. Genetic, phenotypic and environmental correlations computed for females between breast angle at 8 weeks of age and body weight at 4, 8, 24 and 38 weeks indicate that at younger ages the environmental correlations between breast angle and body weight were of greater magnitude than the genetic correlations. Body weight at 24 and 38 weeks of age appeared to be affected very little by 8-week breast angle. This would indicate that artificial selection for or against broad breasts at 8 weeks of age would not result in large changes in body weight at older ages. Texas workers found a negative correlation of 9-week body weight and 9-week breast width. (AH el-44)

Analysis of selection differentials at Washington indicate that selection for large body weight in turkeys reduces hatchability of fertile eggs, and conversely, selection for high hatchability reduces body weight. Realized heritability in the three selected lines for their respective traits were .28 for the growth line, .08 for the egg production line and .40 for the hatchability line. (AH el-46)

5. Genetic Effect on Physiological Traits.

At the North Central Regional Poultry Breeding Laboratory, repeated blood transfusions from Regional Red or Black Regional Dominant hens into White Leghorn hens or from White Leghorn or Black Regional Dominant hens into Regional Red hens administered over three generations failed to produce changes in the inheritance of the feather color of the progeny of the transfused hens. These results are in contrast to earlier Russian reports of changes in feather color genotypes produced in the progeny of transfused White Leghorn hens. (AH el-43)

Research with blood antigens at the Texas and North Carolina stations indicates that certain blood group systems are involved in resistance to fowl typhoid and in hatchability of fertile eggs. The Texas workers found heterozygosity advantageous at some loci but an advantage for the homozygous condition at one locus. (AH el-44)

Research on blood pressure of chickens at New Jersey shows that the two lines developed for high and low blood pressure, respectively, have continued to separate but that the productive performance has not been consistent. However, the hypotensive birds are generally more susceptible to certain physical stresses than the hypertensive ones. (AH el-45)

Studies involving serum cholesterol levels in chickens at Maryland indicate that while the serum cholesterol level varied in the two lines selected for high and low levels, respectively, there was actually very little difference in the yolk cholesterol of the two lines. (AH el-45)

In a study in which skin from various strains and crosses was grafted onto White Leghorn and Rhode Island Red hosts, the Kansas station has shown that effective differentiation by means of the severity of the skin-graft reaction could be made between pure strain donors which were from the same strain as the host, crossbred donors which had a breed in common with the host and crossbred donors which had no breed in common with the host. Sex-linked genes appear to be important in the graft reaction since female crossbred donor tissue containing the x chromosome of the breed other than that of the host, was rejected more rapidly than tissue from female donors of the reciprocal cross. In all studies Rhode Island Red hosts rejected homografts more rapidly than White Leghorns and older chicks sloughed their grafts more rapidly than young ones. That the Bursa of Fabricius is involved in the development of antibodies against the grafts was indicated by heavier Bursas in the grafted hosts compared to the nongrafted controls. (AH el-43)

B. Performance Testing

1. Improving Design of Performance Tests.

Cooperative research with Iowa State University under a contract arrangement was initiated in order to develop improved procedures for testing the performance of poultry.

The first Iowa on-the-farm test consisted of 12 entries tested at 5 farms in a lattice design. The second and third tests involved 16 entries tested on 16 farm units in a quadruple lattice design, which was a more efficient design than the first. Detailed procedures for analyzing results obtained in these designs were developed and the performance data were analyzed with these analytical methods.

The results of this study covering three years of performance testing indicate that genotype x environment interactions of the Entry x Farm type are important for age at sexual maturity, laying house mortality, rate of egg production, egg size and housing body weight. Entry x Farm interaction effects appear not to be important for final body

weight, pullet growing mortality and egg quality measures of performance. The Entry x Farm interaction effect is confounded with the main effect due to entries when comparisons are made at the same test location. This is a source bias which causes an overestimation of entry differences. In the 1959 data this bias amounted to 11% and in 1960 over 33% of the entry variance in the performance index.

Parent-flock source effects may also bias entry comparisons. This is apparently of some importance when each entry originates from a single parent flock. Parent-flock source variance amounted to 13% of the entry variance in the performance index in each of the two years where it was possible to isolate this factor for investigation.

The most efficient test appears to be a multiple location, single-pen, replication type where the entry samples are derived from more than one hatchery or parent flock source.

Coordination of random sample tests has passed from the experimental phase to a regular procedure now to be carried on by the Poultry Improvement Staff, under its Work Project (AH e5). The Poultry Improvement Staff arranges to gather the data from the various State tests, prepares the data for analysis and has it processed by Biometrical Services. Wide dissemination of the combined results is being achieved through an ARS series of publications. (AH e1 35(c))

2. Random Sample Performance Tests.

The results of random sample performance tests have become an important source of information for the use of poultrymen in evaluating the performance capacity of commercially available poultry stocks. The tests terminating in 1961 reported results for 694 entries representing 288 stocks, of which 184 were entered in egg production tests, 52 in broiler tests, and 52 in turkey meat production tests.

The results reported by the egg production tests for 15 traits were combined by stocks and the regressed means computed for each trait for each stock. These computations take into account the repeatability between tests, the number of tests entered, environmental or nongenetic differences between tests, and the level of performance within each test in relation to the other stocks entered. The results of these computations are published in annual summaries which are made available for general distribution. The 1960 and 1961 summaries also included the LSD Range for each regressed mean of each stock. The LSD Range is based on the computed least significant difference at the .05 level of probability and is included in the published summary as an aid to the interpretation of the data.

A combined analysis was made of the results reported by 4 broiler tests in 1961. This analysis indicated that, because of certain weaknesses

in the testing procedures, the combined results would not support valid comparisons and the publication of a combined summary of broiler test results has been postponed.

The results submitted by each of the turkey tests in 1960 and 1961 were analyzed separately. The results of each entry for 24 traits and the application of Duncan's multiple Range Test to 12 of these traits were published in annual summaries. The 1961 test data from all turkey tests were also combined by stocks and the regressed mean and LSD Range for each of 9 traits for each stock were included in a supplement to the 1961 turkey test summary. (AH e5)

3. National Poultry and Turkey Improvement Plans.

It is estimated that about 3/4 of the chicks and poults produced during the last 2 years were from the 2500 hatcheries participating in the Plans. These hatcheries, with capacity for more than 400 million eggs, used only eggs from breeding flocks which were classified under National Plans standards. All of the flocks, composed of more than 40 million birds qualified for a disease control classification and more than 90% also qualified for a breeding classification. Most of the flocks qualified for a breeding class on the basis of physical selection standards. However, the number of flocks classified on the basis of the stocks' performance in random sample tests was substantially greater than in previous years.

The incidence of pullorum and typhoid, as indicated by the number of reactors on first test, have reached a low level at .012%. In order to accelerate further reduction in these infections, work has been started on the development of an air analysis procedure to detect infection in the hatchery. Also, during the past year the procedure for reporting and investigating pullorum and typhoid "breaks" was expanded with a view to reaching previously undisclosed sources of infection. The expanded system involves the cooperation of the Official State Agencies, diagnostic laboratories, State disease control agencies and the ADE field offices.

All shipments of hatching eggs, chicks and poults by Plan participants to points outside the United States are accompanied by a special report (NPIP-15F) on the type and purpose of the stock. This report is intended to clarify misunderstandings which have resulted in the misuse of the stock and subsequent dissatisfaction of the purchaser. Such reports were made for more than 87 million hatching eggs, chicks and poults shipped to 63 countries last year. (AH e5)

C. Selection and Systems of Breeding.

1. Evaluation of Genetic Changes Produced by Various Breeding Systems.

Thirty-nine samples of various breeding systems under study throughout the North Central Region and certain crosses between them were compared with their base control populations for more than 14 economic traits at the Regional Poultry Breeding Laboratory, Lafayette, Indiana. Several breeding systems appear to have produced changes in the selected trait, percent hen-day egg production to January 1. In three generations, the system utilizing sire family selection with restricted inbreeding under study at the North Central Regional Poultry Breeding Laboratory has increased the selected trait by about 3%. Purposeful inbreeding within sire families selected on the basis of percent hen-day egg production to January 1 has decreased egg production by about 3.5%. An increase of 2.1% is apparent after two generations of selection in the system utilizing dam family selection. Three years of selection at Illinois based on individual records has produced little or no change in the selected trait. A randombred control population maintained at Minnesota by mass random mating of 250 breeder females showed no significant changes in egg production from the Regional Cornell randombred control. However, decreasing the number of females in the maintenance flock to 125 appears to have produced a small but consistent decrease in production over the three generations studied. This is suggestive of inbreeding depression due to small numbers of effective breeders. An unexpected increase in egg size of roughly 2 grams seems to have accompanied selection for percent hen-day egg production in the two sire family selection systems at Lafayette, the individual selection systems at Illinois, and the two systems on the maintenance of randombred controls at Minnesota. These systems were all started in 1958 and systems begun since that time have not shown this increase. For this reason, a correlated response in egg size is not necessarily indicated when selection is for hen-day egg production to January 1. An improvement in livability is indicated in many of the selection systems populations. Sexual maturity and egg quality traits have remained unchanged. (AH el-43)

Comparison of recurrent and closed-flock selection for growth rate at New Hampshire indicates a slight advantage in closed-flock selection for hatch of fertile eggs and shank pigmentation. Recurrent selection showed a slight advantage for 8-week body weight, March egg weight, 160-day body weight and March body weight. The work at this Station also suggests that after three generations of selection there was an increase in the closed-flock line and a decrease in the recurrent line in the relative contribution of nonadditive genetic to total variance in body weight. This research also provided evidence that the relative magnitude of nonadditive genetic to total variance in body weight was

greater at 4 than at 8 weeks of age. Indications of sex linked genes affecting yellow shank pigmentation intensity were noted. (AH el-45)

2. Randombred Control Populations.

Randombred populations are widely used as genetic and environmental controls and as a gene pool for use in initiating new research. Four such populations are maintained in the North Central region, two in the Southern region and one in the Northeastern region. (AH el-43, AH el-44, AH el-45)

Four years of data collected at the North Central Regional Poultry Breeding Laboratory on the Regional Cornell control population indicate that the annual egg production has increased from 58.4% in Generation 1 to 68.9% in Generation 4. In a similar period egg weight has decreased from 61.0 to 58.8 grams. Body weight has shown a similar tendency to decrease. With so little data it is difficult to interpret whether these are permanent genetic shifts, environmental time trends or random fluctuations. (AH el-43)

An analysis made by the North Central Regional Poultry Breeding Laboratory of the gene frequencies of ten simply inherited qualitative traits in the Regional Dominant Randombred population indicated no significant changes in these frequencies had occurred over the four generations studied. These results indicate that similarly maintained randombred controls are fulfilling the need of genetic stability, one of the requisites of a good genetic control. (AH el-43)

Most of the morphological traits in the Connecticut randombred population have remained fairly stable during the past seven generations. Exceptions include head spots, which have decreased from the F_3 to the F_6 generations. The percentages were 24.7, 16.3, 11.8 and 8.8, respectively, for these last four years. There has also been considerable variation in the amount of red plumage recorded for this population from the F_1 to F_6 generations. (AH el-45)

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POULTRY - PHYSIOLOGY AND MANAGEMENT
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Problem. Continuing basic research in avian physiology is essential to establish fundamental concepts and to increase the body of knowledge upon which ultimately must depend the resolution of many long standing issues of practical import, e.g., the "problems" of fertility, hatchability, growth and egg production. A continuing flow of basic physiological knowledge is necessary also for implementation of the subject matter of other disciplines. In some important areas, research to date has accomplished little beyond outlining the magnitude of the task at hand. In reproductive physiology, for example, the dominant role of the central nervous system is now generally recognized, but much intensive research will be required before we can expect any "useful" knowledge of mechanisms by which the varying actions of external and internal factors are integrated and directed to initiate, maintain or modify reproductive functions. Many aspects of environmental physiology, of responses to stress, and of growth and development likewise depend upon basic research for the bank of knowledge that can be applied toward useful ends. On the more immediately practical side, increased knowledge of poultry housing, related equipment and other management factors is necessary to provide optimal ranges of operational efficiency.

USDA PROGRAM

This is a continuing program, mainly on basic aspects of the physiology of avian reproduction, but including also applied studies pertaining to environmental physiology and management. In addition to physiologists, the work draws upon geneticists and animal husbandmen. Research is in progress at Beltsville, Maryland, and Glendale, Arizona, the work at Glendale contributing to regional project W-50. Cooperation currently is maintained with members of the Wistar Institute, Columbia University, the National Institutes of Health and the University of Pennsylvania.

Federal research in this area calls for 7.8 professional man-years, distributed to subareas as follows: Physiology of reproduction, 3.2; environmental physiology, 1.0; physiology of growth and development, 1.0; management practices, 1.1; and program leadership, 1.5.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 50.2 professional man-years divided among subheadings as follows: physiology of reproduction, 7.8; environmental physiology, 15.5; physiology of growth and development or other physiology, 13.2; and management practices, equipment and facilities, 12.7.

Reproductive efficiency and the physiological factors affecting fertility and hatchability are under investigation in chickens and turkeys. These studies involve an exploration of the nervous system and the endocrine system and their interrelationships in controlling the process of ovulation in the female and semen production in the male.

Atmospheric stresses on the reproductive performance of chickens is the subject being studied in W-50, where nine States and the USDA cooperate to determine the effects of different combinations of temperature, light and altitude. Basic research studies on stress are coordinated through NC-43, Physiologic Response of Laying Fowl to their Environment. Individual stations are working on light and heat as environmental variables, effects of environmental stress on production, the physiological response to a changed environment, and the effects of seasonal variation.

Hatchability investigations make use of techniques such as hereditary abnormalities, extreme temperatures during incubation, response of embryos to changes in gaseous environment, and X-irradiation. The physiology of the digestive system, the circulatory system and behavior also receive emphasis.

Chicken and turkey management research includes an evaluation of different flock replacement systems, work simplification studies, confinement and range rearing systems and cage and floor housing systems. Incubator management, equipment and space requirement in all phases of production and other factors related to production efficiency are also studied.

Industry and other organizations devoted approximately 50 professional man-years to the field of poultry physiology and management. Most of this work is directed toward new product development by pharmaceutical and feed manufacturers. Basic research is undertaken by only a few companies doing research in this area.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Neuroendocrinology.

As was noted in last year's report, electrical stimulation with stainless steel electrodes of a region just above the median eminence of the hypothalamus appeared to result in delay of the hour of ovulation of the first follicles of the hen's sequences. Work completed during 1961 established strong grounds for believing that stimulation acts by delaying the release of ovulation-inducing hormone (OIH). While stimulation has been applied for a period of only ten minutes in all experiments, the delay in time of OIH release may be as great as 12 to 14

hours. Following upon the discovery by Everett and Radford that the effects of stimulation in the induction of ovulation in the rat are mediated by electrolytically deposited iron, it was shown that the delay of OIH release in the hen may be mediated similarly. The physical basis for long-continued stimulation (or "irritation") of nerve cells or fibres thus seems established, but the nervous and endocrine mechanisms by which the long-time effects are transmitted remain to be elucidated.

Further exploration of the hypothalamus has shown that delayed OIH release follows also upon stimulation of the preoptic region. Placement of electrodes systematically, from bird to bird throughout this area, has shown the effective loci to involve the ventromedian region of the preoptic hypothalamus extending from the median 3rd ventricle out to about 1mm bilaterally.

The fact that electrical stimulation of two regions in the hen's hypothalamus results in an apparent delay in OIH release, while stimulation of comparable regions in the brains of certain mammals causes premature discharge of this pituitary hormone, calls for a more thorough examination of the hen's central nervous system. As an initial step, hens were subjected to diffuse electrical stimulation of the head and spinal cord. These procedures, which are known to force premature ovulation in the mammal, were singularly ineffective in the hen and in many instances led to immediate and rapid regression of the ovarian complement of developing follicles.

In studying the neural control of ovulation in the hen, it is important to determine to what extent the secretion of gonadotrophins depends upon intact connections between the anterior pituitary and the hypothalamus. Trophic function of pituitary autografts to the kidney capsule of laying hens is accordingly under investigation. As adjudged by the rate of post operative regression of the ovary and oviduct, the pituitary transplant does not release detectable quantities of gonadotrophins. On the other hand, an apparently significant difference in the rate of comb regression between hypophysectomized hens and hypophysectomized hens bearing pituitary grafts may indicate that minute quantities of LH are elaborated and secreted into the blood stream. No evidence was found for prolactin secretion. Changes in adrenal and thyroid weights, relative to such changes in hypophysectomized birds, suggest a low level release of adrenotrophin and thyrotrophin. A much lower post operative mortality in hypophysectomized hens bearing transplants than in hypophysectomized birds without transplants is also indicative of some release of adrenotrophin or of thyrotrophin, or of both.

An attempt has been made to determine the approximate time of release of the ovulation-inducing hormone by assaying pituitaries obtained at

varying intervals prior to ovulation of the first or C_1 follicle for residual hormone. The assay unit, determined by preliminary trials, was that quantity of crude, air-dried pituitary powder which would force ovulation in 50 to 60% of 20 or more birds. Pituitaries were obtained from groups of 20 birds killed at intervals of 4, 10 and 14 hours prior to estimated time of ovulation of the C_1 follicle. Birds in a fourth group received an ovulatory dose of progesterone at 14 hours prior to ovulation of the C_1 follicle; the glands were removed 4 hours later, an interval sufficiently long to insure that OIH release had occurred. In a trial involving 126 birds, no appreciable differences were detected in the ovulatory levels of glands collected at any of the four intervals. (AH e3-15)

2. Parthenogenetic Reproduction.

The respective roles played by genetic factors and by live viruses in the initiation and organization of parthenogenetic development continues under investigation. During 1961, approximately 8,000 turkey eggs from virgin and nonmated daughters and granddaughters of an earlier parthenogenetic male were incubated. One hundred twenty-two parthenogenetic poults were hatched, a number almost twice that recorded for all previous years. Twenty-two of these parthenogenetic males matured, three of which have produced semen containing viable spermatozoa. Semen from these three males was used to inseminate virgin and nonmated (older) hens resulting in viable, normal appearing poults. A total of 10 parthenogenetic males have produced semen and 8 parthenogenetic males have sired offspring since 1952, when this project was started. Some of the 22 males produced in 1961 have been utilized in a cooperative study with members of the Columbia University Hospital, New York City.

During 1962, 8,519 eggs from virgin turkeys were examined. Of this number, 3,916 or 46% of the eggs showed some degree of development, the highest average level ever reached. A total of 1,071 embryos was encountered, including 94 poults which pipped and emerged, for the most part unaided, from the shells. Thus 27.3% of all eggs undergoing development gave rise to embryos while 8.8% of them actually succeeded in hatching.

The marked increases each year in the incidence of parthenogenetic development have been achieved largely as an outgrowth of a selective breeding program initiated in 1954. Sons of parthenogenetic males, or of parthenogens themselves when available, have been used as sires. Females likewise have been rigorously selected for their capacity to reproduce parthenogenetically.

Along with yearly increases in the incidence of parthenogenesis, there have also been significant changes in the proportion of organized to unorganized development. In 1952, only 1.3% of the eggs undergoing

parthenogenetic development gave rise to embryos. In 1962, 27.3% were so classified, representing a 21-fold increase over a 10-year period. Furthermore, the embryos which do develop are now surviving longer, on the average. In 1954 only 15.9% of all parthenogenetic embryos lived longer than 10 days, in contrast with 47.3% of all embryos still alive at 10 days of age during 1962.

The possible effects of live viruses in the induction and organization of this asexual type of development continues to be investigated. Additional data lend further support to the view that live fowl pox virus causes a significant increase in parthenogenesis in unfertilized turkey eggs. An increase in the incidence of the unorganized type of parthenogenetic development was also recorded following inoculation of turkey hens with live Rous sarcoma and Newcastle disease viruses. No increase was noted, however, when turkey hens of similar breeding were inoculated with killed fowl pox, Newcastle or Rous sarcoma viruses.

Significantly, the incidence of twinning among parthenogenetically developing embryos appears to increase following repeated use of live fowl pox virus. Monozygotic twins, triplets, etc., have been found in as high as 17% of eggs showing true embryo formation. Eight, three day old, parthenogenetic embryos was the greatest number found in a single yolk egg.

While certain live viruses have been shown to be associated with parthenogenetic development, it is also clear that the inheritance of an individual also plays a role. The exact contributions of each component have not been adequately demonstrated. To obtain more critical data on the relative roles of viruses and genetic factors, a cooperative experiment has been initiated with Pennsylvania State University. Since live fowl pox virus is not employed as a vaccine at Pennsylvania State it became feasible to study genetic factors both in the presence and in the absence of the virus. Fifty pedigreed, non-vaccinated turkey hens, furnished by the University, were segregated into two groups consisting of equal numbers of full sisters. One group of 25 hens was brought to Beltsville and there vaccinated for fowl pox. The other group of 25 birds was retained at the University as non-vaccinated controls. Unfertilized eggs from birds of both groups were incubated 10 days before being broken and examined in the usual manner. Nonvaccinated turkeys at Pennsylvania State University produced 734 unfertilized eggs, of which approximately 1% underwent parthenogenetic development. Vaccinated birds at Beltsville produced 1,262 eggs, with 5.55% of this number exhibiting parthenogenetic development. The experiment will be continued to ascertain the effectiveness of selection in increasing the incidence of parthenogenesis in vaccinated and non-vaccinated lines of common origin.

Information on the possible site and mode of action of viruses was obtained through the cooperation of Drs. Ray Bryan and Frank Rauscher

of the National Institutes of Health in a study to determine if virus, following inoculation of the hen, entered immature ova and could be recovered from eggs. A Black Minorca hen was inoculated intravenously with a potent strain of live Rous sarcoma virus. Fertilized eggs were obtained following insemination of this hen with semen from an unvaccinated Dark Cornish male. An extract, prepared from fourteen day embryos, was used as an inoculum and injected into 4-8 week old cross-bred chickens which had been found free of antibodies to Rous sarcoma virus. Thirty days after inoculation, samples of blood were obtained and retested for presence of antibodies. The tests were repeated, using a second set of 4 crossbred chickens. Three of the 8 chickens developed fairly high antibody titers. No live virus could be recovered from newly laid eggs using conventional methods. The results suggest that virus, if present in eggs, is probably in the form of infectious DNA. (AH e3-19)

Two skin transplantation researches have been completed, using the chicken x turkey hybrid and the parthenogenetic turkey as experimental animals. The first, a cooperative effort with Drs. R. E. Billingham and W. K. Silvers of the Wistar Institute of Anatomy and Biology, involved reciprocal skin grafts between adult chicken x turkey hybrids and between these hybrids and unrelated members and the parental species. The results were unequivocal rejection of all grafts, regardless of donor, by the hybrids. Furthermore, hybrid whole blood inoculated to the chorio-allantoic membranes of chick embryos consistently produced embryonic splenomegaly. These findings clearly demonstrate the capability of the hybrids to recognize and react against foreign transplantation antigens. They are of particular interest in relation to the apparent lack of specificity of immunological tolerance of tissue grafts alleged to occur following chicken-turkey embryonic parabiosis.

The second, a cooperative project with Drs. Wm. V. Healey and Paul S. Russell of Columbia University, College of Physicians and Surgeons, involved reciprocal transplantation of wattle skin homografts between parthenogenetic Beltsville Small White turkey males and their dams, and a comparison of their survival times with similar grafts between normal nonparthenogenetic Beltsville Small White turkeys. Eleven grafts from parthenogenetic males to their dams have survived, some now more than 16 months, while the reciprocals were rejected in about two weeks. Similar grafts from normal turkey males to their dams survived approximately 21 days with subsequent complete rejection. Such grafts in randomly selected nonparthenogenetic turkeys were rejected in approximately 9 days with a second set reaction occurring at about the fourth day. These findings clearly demonstrate that there are no transplantation antigens present in the parthenogens which are not present in their dams, and prove that such birds are fully competent of reacting against "foreign" transplantation antigens present in their dams in a heterozygous condition. Further, they lend strong additional support to the contention that these eleven males are of parthenogenetic origin.

A further experiment is underway with the Columbia group to determine the responses elicited by reciprocal wattle skin homografts between parthenogens and their progeny by unrelated females. All homografts from progeny to parthenogens, and all except one homograft from the parthenogens to their progeny, have been rejected. The exceptional graft has not retained the appearance and texture of normal wattle skin, though there has been no clear evidence of a homograft reaction against it throughout the more than two months since it was transplanted. The rejection of the progeny of their parthenogenetic sire's skin is most significant in demonstrating that the parthenogen is heterozygous at one or more histocompatibility loci. Together with other observations, these results indicate that either nondisjunction at the second meiotic division or re-entry of the second polar body is the cytogenetic mechanism by which the diploid chromosome complement is established in the parthenogen. This work is presently being extended by regrafting a second set in the first group of birds, and by additional homograft exchanges between all available parthenogens and their progeny by unrelated females.

The survival time of reciprocal skin homografts between sibs and between dam and male progeny in the Beltsville Small White line selected for parthenogenesis is being used as a major selection criterion in an attempt to establish a line or lines of turkeys isogenic for transplantation antigens. Pairs which bear grafts of long time survival are being used as replacement flock matings and it is hoped that transplantation antigen isogenicity will be achieved in a few generations. Such selection techniques will also be applied in a colony of Japanese quail now being established in the Physiology Investigations Section. (AH e3-19 and e3-20).

An autosomal recessive mutation which in the homozygous condition produces nearly complete nakedness has arisen in Beltsville Small White turkeys. Symbol na has been proposed to designate this mutation. Crosses of heterozygous carriers produce a 3:1 ratio of normal to naked poults with no evidence for sex linkage or sex limitation. Progeny by artificial insemination of heterozygous females with a homozygous naked male's semen are in a 1:1 ratio of normal to naked. Only remigial feathers plus an occasional down feather are present on naked poults. The skin is otherwise devoid of feather follicles. Toenails and beak are normal but there are no scales on the shanks and feet. Gross anomalies of the hind limbs are common on either or both feet of most naked poults. Whether this polydactylism is the result of a separate but closely linked gene or a pleiotropic effect of the naked mutation is not known.

B. Environmental Physiology

1. Long-term Responses.

Work was continued, in collaboration with the Farm Electrification Branch of Agricultural Engineering on the reproductive responses of Beltsville Small White turkeys to environmental variables. Six pens of birds were maintained in a force-ventilated windowless house at $60^{\circ} \pm 5^{\circ}$ F., with some modulation of humidity; two pens received initially (Dec. 19, 1959 and Dec. 20, 1959), 11, two pens 13, and two pens 15 hours of artificial light daily. The performance of these "inside" turkeys was compared with that of six groups of "outside" birds maintained in conventional windowed houses with grassed yards; natural daylight was supplemented with artificial light each morning to provide initial photoperiods of 11, 13, or 15 hours in replicated pens. Photoperiods of both "inside" and "outside" birds were lengthened gradually with the later hour of sunset as the season progressed. No important differences were observed in egg production, fertility, hatchability and length of the breeding season in either "inside" or "outside" birds under 13- or 15-hour photoperiods. "Inside" turkeys under 11-hour photoperiods produced almost as many, 90 versus 97 eggs, as did birds under 13 or 15 hours of light, and compared favorably with hens under the longer photoperiods in all other respects. "Outside" turkeys under 11-hour photoperiods failed definitely to equal the egg production of "inside" birds under the same length of photoperiod (81 versus 90 eggs). The reason for this difference between "inside" and "outside" turkeys under similar photoperiods is not clear. When egg production records for "inside" and "outside" birds are combined for the 19-week breeding period ending May 31, turkeys under 11-, 13-, and 15-hour photoperiods produced an average of 83.0, 94.8, and 98.7 eggs, respectively, per hen. Except for some possible but unlikely influence on "inside" hens under 11-hour photoperiods, it appears that the temperature and humidity controls to which the "inside" birds were subjected in no way enhanced their reproductive performance.

It has been shown previously that out-of-season turkey hens (those hatched from eggs laid between September 1 and March 1) do not respond well in egg production to a further increased photoperiod. To elicit a favorable response, such hens must be subjected to a reduction in the amount or duration of the light received in the period immediately preceding egg production. A shortened light day, 6 to 9 hours, for a period of 3 weeks or longer has been shown in preliminary experiments, and by other investigators, to be effective in eliminating the failure to respond to increased photoperiods. In current tests, an 8-hour light period was compared with a "brownout" supplying below 0.1 foot-candle of incandescent white light during the hours of natural daylight between the ages of 20 and 30 weeks, after which the photoperiod was extended directly to 15 hours and increased gradually to 17 hours.

The "brownout" proved to be as effective as the 8-hour light day in preparing the hens for a successful breeding season. (AH e3-18)

Chickens hatched out of season have different patterns of egg production, and controlled photoperiods offer the possibility of achieving optimum performance. At Glendale, Arizona, three treatments included normal daylight to 20 weeks of age, 8 hours of light to 14 weeks of age then 16 hours to 20 weeks, and 16 hours to 14 weeks then 8 hours to 20 weeks of age. Differences over a 3-year period indicate that short 8-hour days to 8 weeks followed by 16-hour days to 20 weeks cause earlier sexual maturity and slightly lower annual production. There was little difference between normal daylight and the treatment involving 16 hours of light to 14 weeks followed by 8 hours to 20 weeks. It is possible that the latitude at Glendale does not cause as much seasonal variation due to hatch date as more northerly latitudes. Gradual changes in length of photoperiods may have a greater effect than the abrupt changes in photoperiods of this experiment and will be studied. (AH e3-16)

2. Environmental Chambers.

Work in this subarea is carried on in cooperation with the Livestock Engineering and Farm Structures Research Branch of the Agricultural Engineering Research Division.

Studies on the heat and moisture production of laying hens in cages and on litter were made and the results published. The heat and moisture dissipation data of these studies may be used for designing poultry houses. The common value of 5 to 6 BTU per hen per hour was found. The ratio of latent and sensible heat varied with the ambient temperature. On a weight basis S. C. White Leghorns produced the greatest amount of heat and N. H. x Cornish crosses the least. Turkeys of the Beltsville White breed were found to produce 4.7 to 5.8 BTU per pound per hour. The latent heat and sensible heat were about equal at temperatures 65° to 80° F.

General observations were made on the housing of broilers, weather conditions and the condemnation losses on processing inspection.

Further work is being planned on heat and moisture production of growing broilers and a strain of S. C. White Leghorns that may have heat tolerance in relation to egg production. Five environmental control chambers are being constructed to acclimatize the birds used in the calorimeter studies. (AH e3-13)

C. Physiology of Growth and Development

This work is an integral part of the research under (A) Physiology of Reproduction, (2) Parthenogenetic Reproduction, and is reported there in the interest of readability.

D. Management Practices

1. White Leghorn pullets, kept one bird to a 10" cage, 5 birds in a 24" cage and 8 birds in a 24" cage, indicate that multiple bird cages decrease egg production (from 134 to 123 to 115) and increase mortality (from 14% to 16% to 23%). Increases in mortality were evident in spite of debeaking to help control cannibalism. It is expected that more emphasis will be placed on the effect of environment on egg quality in future experiments. (AH e3-17)

2. Studies were undertaken to observe the practical value of dipping hatching eggs in an erythromycin solution as a means of reducing M. gallisepticum (PPLO), mortality, and condemnations.

Based on the results of two trials, it was observed that the dipping of eggs to control egg-transmitted Mycoplasma gallisepticum infection may depress hatchability under certain conditions which are not fully understood at present. There is an indication that the dipping of eggs may have produced chickens better able to survive cold room and hover conditions during the first two weeks of life. The dipping procedure was not always effective in either reducing mortality, condemnations, or the amount of M. gallisepticum (S₆ type PPLO) in the blood stream of broilers about 9 weeks of age. More work is needed to perfect methods of dipping eggs of practical value in commercial broiler production. (AH e7-1)

3. In a continuation of studies of the effect of light during the growing and laying periods on egg production, three different light treatments were used during the growing period: (A) 6 hours of light daily, (B) started with 22 hours and over the growing period decreased at weekly intervals to 6 hours, (C) normal daylight. The chickens on each growing treatment were divided into two groups when placed in the laying houses with each receiving a different light treatment. The results are as follows: Growing treatment A - 14 hours of light resulted in better performance than starting with 6 hours with weekly increases to 24 hours; Growing treatment B - starting with 6 hours with weekly increases to 22 hours gave better production than 14 hours; Growing treatment C - 14 (daylight plus artificial light) gave better results than starting with 6 hours of light with a weekly increase to 24 hours. (AH e2-14).

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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Physiology of Growth and Development

None (See Physiology of Reproduction)

Management Practices

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POULTRY - NUTRITION
Animal Husbandry Research Division, ARS

Problem. The goal of nutrition research is to amass information so that poultry diets may be formulated and fed to produce the best quality product at the least possible cost. The problem logically divides into two areas: (1) furnishing the nutritive requirements of poultry, and (2) the feedstuffs that supply these requirements. A refined methodology is needed to estimate more accurately the energy (carbohydrates and fats), protein (amino acids), vitamin and mineral requirements of poultry of various ages, strains and level of production. But, even more urgently needed is information on the relationships that exist between these nutrients, if the formulation of optimum nutritive balance in diets is ever to be attained. Additional information is required on the effect of feed additives (antibiotics, arsenicals, hormones, enzymes, antioxidants, tranquilizers) on nutritive requirements, and on the utilization of protein and energy. Somewhere in the maze of requirements, interrelationships and interactions, it must be determined which portion of the diet is for intestinal microorganisms and which is for the host. Also, the vast field of interrelationships between disease and nutrition remains to be explored. In the feedstuffs area, how much of a particular nutrient that is present should be known, but of more importance is how much is available to the bird. Thus, information on digestibility, absorption, chelation and interactions is necessary. In addition, the complete composition of a feedstuff must be known. At the present, the proximate analysis is the only information available about major dietary constituents, consequently, the nutritionist does not know exactly what is being fed when a diet is formulated. There may be present growth promotants and/or inhibitors of which he is not aware. As a case in point, over 200 chemical compounds have been isolated from citrus fruit.

USDA PROGRAM

This is a continuing program conducted by nutritionists on basic and applied research on the nutritive requirements and digestion and metabolism of poultry and the nutritive value of feedstuffs. The work is in progress at Beltsville, Maryland, and at the Southwest Poultry Experiment Station, Glendale, Arizona. Some phases of work at Glendale are carried on in cooperation with the Departments of Biochemistry and Poultry Science of the University of Arizona at Tucson.

The Federal effort devoted to research in the poultry nutrition area totals 8.0 professional man-years. Of this number 3.7 are devoted to nutritive requirements, 2.0 to digestion and metabolism, 1.9 to the nutritive values of feedstuffs, and 0.4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported 64.6 professional man-years divided among the subheadings as follows: nutritive requirements 32.8, digestion and metabolism 15.2, nutritive value of feeds 16.6. Some phases of research on poultry are being conducted at practically all of the State experiment stations; however, in a few States there is little or no work on nutrition. In contrast, there are many stations where nutrition research is predominant in the poultry program. Because of changes in diet formulation to obtain high-energy diets and the concurrent introduction of more refined and also new feedstuffs, the basic nutritive requirements of poultry are being re-evaluated. This work is concerned with sources of energy, amino acids, vitamins and minerals, particularly trace minerals. The interrelationships between nutrients are under investigation, along with the effects of disease level on nutritive requirements.

Studies are being conducted to determine more precisely the interrelationship of avian genetic constitution with the utilization of nutrients and the productive performance of poultry. The effect of feed additives on nitrogen metabolism, various body tissues, intestinal microflora, and physiological functions is being investigated with emphasis on the mode of action of these materials. Other basic research is concerned with the catabolism of amino acids in the liver and kidney, the utilization of yolk-sac calcium and phosphorus by the newly hatched chick and the absorption of minerals using radio techniques. Studies are being conducted on the nutritive properties of imported and locally grown feedstuffs in order to formulate the most economical and adequate rations. The biological value of different forms of feed (mash, pellets, crumbles, mash and grain combinations) is under investigation. Also, green feeds as a source of vitamins, and the improvement in feeding values of cereal grains by water and enzyme treatment are being studied. There is some work in progress concerned with the growth inhibiting principles in feedstuffs.

Industry and other organizations orient their research efforts primarily toward product development. This is particularly true with feed manufacturing companies where nutrition is practically entirely of an applied nature. Some pharmaceutical companies which supply the feed industry with various ingredients are conducting some basic research, but this is usually in connection with their products, and is seldom published. It has been estimated that this activity amounts to about 80 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Nutritive Requirements1. Fat Requirements.

A highly significant increase in chick growth rate was obtained when fat calories were substituted for carbohydrate calories on an isocaloric and isonitrogenous basis. This was true for equalized nutrient intake as well as for ad libitum feeding. If growth response to egg oil is due to the presence of a growth promotant, the results of this work indicate that lard, corn oil, soybean oil and coconut oil also contain a common growth stimulant. Animal fat was as effective as vegetable oils in growth stimulation. The relatively more saturated lard, coconut oil and egg oil were just as effective as the less saturated corn and soybean oil.

When additional studies indicated that unsaturated fatty acids or a growth promotant might be involved in the growth stimulation attempts were made to inactivate the growth promoting ability of oil by heat, oxidation or hydrogenation in order to elucidate their role in growth. None of the treatments except hydrogenation has any effect on growth. The hydrogenated oil gave no response. (AH e2-13)

2. Protein and Amino Acid Requirements.

In a series of experiments to study the interrelationship of energy and sulfur-amino acids in growing turkeys, methionine was added to different basal diets to provide a range from 1.93 to 3.85 grams per therm of metabolizable energy. No significant interaction between basal diets and supplemental level was found, thus, indicating that the different basal diets had no effect on response. There was a significant response to sulfur-amino acid supplementation. The data indicates that amino acid requirement can best be expressed as a function of energy.

Studies on the protein requirements of pullets during the growing period indicated that a 21% protein diet from hatch to 8 weeks followed by 16% throughout the growing period, or 16% to 8 weeks followed by 12% to housing time supported better growth than did 16% throughout the growing period, or 16% to 8 weeks followed by 12% to housing time. In the first study conducted in floor pens, the results showed that on a 12% protein laying diet, the egg production was higher among pullets grown on 21% followed by the 16% protein diet than on the other two growing treatments. The second test which was conducted in laying cages did not confirm this result. In this study the grower diets had no effect on egg production, egg weights, feed conversion, or body weight gains irrespective of hen diet. The 14, 16, and 18% protein

levels in the hen diet showed no differences in egg production, egg weight or feed conversion. However, the 12% protein level resulted in lower production, smaller eggs and poorer feed conversion. (AH e2-16)

3. Mineral Requirements.

In work with trace minerals the individual addition of copper, molybdenum, potassium, zinc, and iodine to a practical type corn-soy diet used as a biological assay diet failed to elicit a growth response. In contrast, the addition of a commercially prepared trace mineral mix produced a highly significant response in the majority of the trials in which it was tested.

An 8-week test was conducted to study the effect of calcium and phosphorus levels on growth rate and bone calcification of two commercial broiler strains. The test involved two energy levels and calcium levels of 0.9, 1.0, 1.1, and 1.2% and total phosphorus levels of 0.5, 0.6, 0.7, 0.8, and 0.9%. The significant effects were strain, sex, energy, and phosphorus levels. The best growth was obtained at the 0.7% phosphorus level. The calcium levels used were not in the critical range and the responses were due entirely to phosphorus levels. The calcium and phosphorus levels used had little or no effect on bone ash or the calcium content of the bone ash.

Based on the information obtained in the first test, a second test was conducted with the calcium and phosphorus levels in a more critical range. In this trial the sexes were separated and calcium levels of 0.5, 0.6, 0.7, and 0.8%, and total phosphorus levels of 0.5, 0.55, 0.6, 0.65, and 0.7% were used. The significant responses were, calcium, phosphorus, sex and calcium x sex. The best growth was obtained with calcium levels of 0.7 and 0.8% with phosphorus levels of 0.55, 0.6, and 0.65%. From 0-6 weeks, feed conversion was influenced by calcium and phosphorus levels and sex. This effect was partially lost during the last two weeks, since 0-8 week data show responses only with phosphorus and sex at a lower level of significance. Bone ash at 8 weeks was significantly influenced by calcium and phosphorus and the ash of bones from females was significantly higher than that of the males. (AH e2-18)

B. Digestion and Metabolism

1. Metabolism of Fats.

In studies on the effect of type of dietary fat on plasma and liver cholesterol concentration in female chicks, it was found that the addition of 3% fat or oil to the diet without cholesterol supplementation did not increase plasma or liver cholesterol concentration. When 0.5% cholesterol was added to the diet, the type of oil had a definite effect. Chicks fed lard or vegetable oils had significantly

higher plasma cholesterol levels than did any of the chicks fed fish oils. Redfish oil was more effective than other fish oils in lowering liver cholesterol concentration. Addition of vanadium to the diet did not give reduction in cholesterol concentration in plasma or liver.

The effect of feeding egg yolk on the serum and yolk cholesterol content of hens was investigated. A diet containing 5% yolk, which furnished 1.6 grams of cholesterol per kilogram of diet, was fed to hens for about 4 years. At the end of this time there were no apparent differences between the cholesterol content of yolk and serum of the hens that received the egg yolk and those that had been fed the same diet without the yolk.

Results of studies on the effect of dietary fat on tissue fat and plasma cholesterol levels in broilers showed that the addition of corn oil and lard increased the fat content of breast and thigh muscle. Lard or corn oil did not increase the plasma cholesterol level. However, both plasma and liver cholesterol levels were increased when 12% yolk was included in the diet.

Laying hens fed a low-fat diet (0.36% fat by acid hydrolysis procedure) maintained body weight, but egg production and egg weight decreased. The oleic acid content of plasma and egg yolk increased, whereas the linoleic acid content decreased. At the end of the experimental period, the fatty acid content of the heart, liver, spleen, breast muscle, thigh muscle, abdominal fat and skin was determined. In contrast to the plasma and yolk it was found that some of the tissues of the fat depleted hens contained as much linoleic acid as those of the controls, and in some instances the arachidonic acid levels were higher. These results indicate that long-feeding periods of diets very low in fat will be required to determine if certain fatty acids are essential in the diet of the chicken.

Since it is known that the fat in the skin of turkeys becomes rancid much quicker than that in chickens, experiments were conducted to determine the fatty acid composition in the skin of these two classes of poultry. This was done by analyzing the extracted fat by gas liquid chromatography. The major difference in fatty acid content between the turkey and chicken was observed in the eighteen carbon polyunsaturated acids. The former contained approximately 60% more linoleic acid and 50% more linolenic acid than did the latter. Only trace amounts of arachidonic acid were found in the skin fat of either species. (AH e2-13)

2. Effect of Additives on Feed Utilization.

Studies conducted at Glendale to determine the effect of antibiotics and other additives on egg production in high ambient temperatures showed that furazolidone, bacitracin, oleandomycin, erythromycin

thiocynate, atteramin, and a combination of penicillin and streptomycin were of no benefit.

Further studies at Glendale, in cooperation with the University of Arizona, indicated that high levels of dietary antibiotics during hot weather had no appreciable effect on egg weight or shell quality.
(AH e2-15)

C. Nutritive Value of Feeds

1. Effect of Feeding Cottonseed Meal or its Constituents.

In studies at Glendale it was found that the "pink whites" in eggs caused by feeding cottonseed meal disappeared 4 days after cottonseed meal feeding was stopped. Further work with the cooperation of the University of Arizona in the cottonseed meal-gossypol area showed that discoloration in eggs from hens given crystalline gossypol was intensified when *sterculia foetida* oil was fed at the same time. This discoloration is probably due to the formation of a ferrous iron gossypol complex in the yolk at an alkaline pH. In additional studies with this oil, sterculyl alcohol was methylated and reduced to form the methoxyl and hydrocarbon derivatives. These two derivatives, sterculyl alcohol and polymers of sterculic acid and methyl sterculate, were fed to laying hens. The sterculic derivatives caused pink egg formations, but the polymers did not. Other studies have shown that neither the "available gossypol units" method, nor the ammonia test were accurate in predicting if yolks from layers fed cottonseed meal would be discolored after storage. It is postulated that a combination Halphen test and ammonia test would give reasonably accurate predictions.

Subsequent investigations at Glendale, in cooperation with the Southern Utilization Research and Development Division have indicated that pink whites in stored egg resulting from feeding cottonseed meal to laying hens is directly correlated with the Halphen positive constituent of the meal. This constituent induces an increase in the pH of the yolks during storage and the development of color is enhanced by the presence of the constituent, since the chromogen responsible for the brown color is pH sensitive.

Studies were conducted to determine the effect of combinations of antibiotics on the growth response of chicks fed fish solubles. The combinations were made up of antibiotics of broad and narrow spectrum effective against gram positive and gram negative organisms and an antifungal antibiotic active against yeasts. The antibiotic combinations failed to promote a more rapid growth rate and did not have any effect on feed efficiency. If the mode of action of antibiotics is concerned with intestinal flora, the materials used failed to remove effectively the complicating influence of intestinal bacteria.
(AH e2-17)

2. Nutritive Value of Grains.

Results of experiments on the nutritional significance of the proteins of corn and barley in laying diets indicated that a 10% protein diet containing corn was equivalent to a 14% protein diet containing barley in supporting egg production. In diets containing 10, 12, 14, and 16% protein when barley was replaced by corn, egg production was improved from 3 to 10%. (AH e2-16)

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POULTRY - IMPROVEMENT OF VIABILITY
Animal Husbandry Research Division, ARS

Problem. Effective disease control is the number one problem facing the poultry industry today. One disease, lymphomatosis or avian leukosis, has ranked at the top for more than 30 years for its devastating effect on the health of chickens and the economics of their production. Basic information is needed regarding the biological and physical characteristics of the agent or agents causing visceral lymphomatosis and related neoplasms. Such information is a prerequisite of the formulation of sound research programs directed toward the development of control measures. There is need for a rapid and accurate method of bioassay to make possible many important studies on the biological expressions of the virus of visceral lymphomatosis and related neoplasms. Breeding studies involving induced lymphomatosis do not give clear genetic results. Genetic testing of inbred lines of chickens for the different disease entities involved in the avian leukosis complex will assist in clarifying the total problem. Nutrition, environment, and management undoubtedly influence the incidence of this disease. A coordinated attack on this major problem from every scientific standpoint is vitally essential.

USDA PROGRAM

This basic and applied research is conducted by pathologists, geneticists and animal husbandmen at the Regional Poultry Research Laboratory, East Lansing, Michigan. Some of the studies have as their objective the biological and physical characterization of the agent or agents causing visceral lymphomatosis and related neoplasms of the leukosis complex. Research is also underway on the pathogenesis of the three primary types of avian leukosis and other related neoplasms for the purpose of determining and evaluating their etiological, pathological, and immunological relationships. Efforts are also being made to develop a more rapid means of propagating in chickens the virus of visceral lymphomatosis than the orthodox method of producing it naturally or by inoculation.

Research on the pathogenesis of the three primary types of avian leukosis and other related neoplasms has included the collection of varying strains of the virus from flocks of chickens located in different sections of the United States. The responses when the viruses from the different sources are inoculated into chickens are being compared to ascertain their identity within the leukosis complex. This cooperative effort is supported financially by the American Cancer Society.

There are two phases of the genetics work related to avian lymphomatosis. One involves the development and maintenance of inbred lines

characteristically different in their resistance to lymphomatosis and related neoplastic diseases. One susceptible line is maintained in isolation to minimize infection with the disease. These lines provide relatively uniform experimental material for the study of nongenetic factors controlling disease expression and incidence. The second phase involves studies of the modes of inheritance of genetic differences in resistance to lymphomatosis and related neoplastic diseases. An objective of the second phase is to find efficient ways of identifying chickens genetically resistant to lymphomatosis as expressed by low mortality under field conditions.

An effort is being made to develop a vaccine that will be effective in the control of visceral lymphomatosis. Studies on the relation of cod liver oil in the diet to the incidence of avian leukosis are being conducted through a contract with the Wisconsin Agricultural Experiment Station, Madison, Wisconsin.

A cooperative project entitled, "Studies on the epizootiology of avian lymphomatosis and related neoplasms" calls for the active cooperation of (1) the Epizootiology Section, Epidemiology Branch, National Cancer Institute, (2) the Animal Disease Eradication Division, ARS, (3) the Regional Poultry Research Laboratory, ARS, and (4) the Poultry Industry Research Foundation. In addition, close liaison will be maintained with the State agricultural experiment stations where studies may be conducted.

The Federal scientific effort devoted to the research in this area totals 9.4 professional man-years. Of this number, 4.0 are devoted to studies of the causative agent of avian lymphomatosis; 1.0 to improvement through genetic methods; 2.7 to improvement through vaccination, feeding and management practices; and 1.4 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations in 1961 reported a total of 4.5 professional man-years divided among subheadings as follows: improvement through genetic methods 3.1 and improvement through vaccination, feeding and management practices 1.4. An attempt is being made to identify biochemical differences in genetic systems between strains of chickens susceptible to disease, and those resistant to the same disease. Major emphasis is given to leukosis. Genetic correlations are being measured between biochemical genetic characteristics and subsequent performance. The practical value of results on such studies, together with research on stress factors as affecting physical expression of susceptibility or resistance, is being tested in breeding programs for the development of resistant stock. Some of this research is being conducted in cooperation with USDA.

The relationship of proper nutrition and management to the control of disease, primarily leukosis, is being determined. The effect of high temperature, poor ventilation, filth, and other stress factors on the incidence of disease also is being investigated.

Industry and other organizations devote about 10 professional man-years on avian tumor research. Most of this is on Rous sarcoma and is done in medical schools or medical research laboratories.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Studies of the Causative Agent of Avian Lymphomatosis

1. Characterization of Field Isolates of Leukosis Virus.

In extensive studies on the characteristics of new field isolates of leukosis virus, tumor, blood and other materials were obtained from 22 flocks located in various parts of the United States and having high mortality from lymphomatosis. Transmission was effected in line 151 chickens with cell-free inoculums of 19 of the 22 sources. The inoculum from one source was obtained from chickens with neural lymphomatosis, a second source from chickens with ocular lymphomatosis and a third source from a chicken with a nephroblastoma. All other inoculums were from chickens with visceral lymphomatosis and mostly from flocks with an early high incidence. The incidence of neoplasms induced varied considerably, although material from nine sources caused at least 50% mortality from neoplasms. In the experimentally infected chickens mostly visceral lymphomatosis was induced. Almost all inoculums also caused erythroblastosis. Other neoplasms induced were sarcomas, endotheliomas, nephroblastomas, osteopetrosis and neural lymphomatosis. Ocular lymphomatosis was not observed. Virus from eleven sources was studied in serial passage to characterize the oncogenic spectra and viral potency. For most of these virus strains at least four passages were made with both visceral lymphomatosis and erythroblastosis donor material.

Serial passages with visceral lymphomatosis tumor extracts have generally caused primarily visceral lymphomatosis; however, in a few passages many cases of erythroblastosis also occurred. Serial passages with extracts of livers from birds with erythroblastosis have generally caused erythroblastosis and in certain instances a high percent with sarcomas, endotheliomas, or osteopetrosis. Bioassays have shown that four passages with erythroblastosis cases have resulted in about a 10,000 fold increase in viral potency. None of the potent isolates have caused visceral lymphomatosis in line 151 chickens in less than about four months. Invariably when the virus titer was increased the birds died early of erythroblastosis. This increase in potency was accompanied by an increase in the number of different types of neoplasms

induced. A reduction in dose of virus inoculated causes primarily the induction of visceral lymphomatosis with a concomitant narrowing of the oncogenic spectrum. Further decrease in dose resulted in a decrease in the incidence of visceral lymphomatosis. Age of the chicken at the time of infection also markedly influenced the oncogenic spectrum. Generally, the younger the bird when infected, the more likely the occurrence of various types of tumors and accordingly embryos were found the most responsive. Intravenous inoculation of 11-day old embryos has resulted in a wide range of different neoplasms.

The avenue of exposure or route of inoculation and the genetic constitution of the host are other factors which have been found to markedly affect the oncogenic expression of a particular strain of virus.

The data obtained definitely points to a single virus that can cause erythroblastosis, visceral lymphomatosis, osteopetrosis, fibrosarcoma, endotheliomas and nephromas and that the several field virus isolates and strains recently studied are essentially similar. There was noted minor, yet notable and continuous differences in the pathologic characteristics between the several viral strains. Such differences may not reflect variations in antigenic constitution and thus are only of minor importance; however, they have been found to be quite stable in serial passage suggesting that they have a genetic basis.

The 11-day old chicken embryos when inoculated intravenously with a leukosis virus develop and hatch normally; however, neoplasia soon develops and death occurs in a much shorter time than if infection was delayed until after hatching. This procedure has been found to be particularly advantageous when many virus samples are assayed, such as for neutralization tests because they can be done in a much shorter time with a saving in cost and in pen space. It is also particularly useful in studies of the oncogenic spectrum because the embryo is much more sensitive than the chick in the development of various types of tumors. Another outstanding feature of embryo inoculation at 11 days is the fact that one avoids the effect of any maternal antibodies in the egg. Such antibodies are not transferred to the embryo from the yolk sac until about the thirteenth day of incubation. Thus inoculation on the eleventh day results in an infection without the effects of antibody. This is particularly important in measuring the genetic resistance of chickens without influence of other factors. Certain commercial crosses have been found to be quite susceptible to strain RPL 12 virus when inoculated as 11-day embryos but resistant when inoculated as day-old chicks. Other crosses were resistant when infected as embryos as well as chicks. The difference in the former crosses may have been due to antibody which is unrelated to innate resistance. (AH e6-10)

2. Serological Tests.

The in vitro neutralization test has been the primary procedure used in studies on the antigenic relationship between various viral strains and isolates. Measurement of unneutralized virus has been done by three different assay methods, i.e., inoculation of chickens, inoculation of embryos and the tissue culture RIF test. Most of the studies have been made with the leukosis strains RPL 12, 26 and 29, and with the Rous sarcoma virus (Bryan strain). Hyper-immune serums have been prepared in chickens. These serums, as well as serums from chickens in the field that have suffered natural outbreaks, were studied. It was found that most serums from natural infections that neutralize strain RPL 12 or other leukosis viruses also neutralize the Rous sarcoma virus. The discrepancy appears to be less than 10%. Thus the more simple and rapid Rous virus neutralization test can be used with confidence in field surveys on the occurrence of leukosis antibodies. This is a confirmation of findings by others.

Considerable antigenic variations among the several sources of leukosis virus were detected. Some of the newly isolated field viruses appear to be antigenically more diverse than strain RPL 12 and the Rous sarcoma virus. Viruses with similar oncogenic spectra may not have the same antigenic structure. The data strongly indicate that the antigenic variation of viruses causing different outbreaks in the field is sufficiently great to be of importance in the development of vaccines and the selection of antigens for serological tests.

The lack of a simple rapid serological test useful for the detection of antigen or antibodies of the leukosis viruses has been the largest obstacle in the development of control measures for this disease. Recently notable advances have been made in this area. The complement fixation test has now been modified to the extent that it can be used to detect and measure the Rous sarcoma virus antibodies. The sensitivity of the test is somewhat less than the neutralization test but detection and assay correlation of serums were very good. Lymphomatosis antibodies in turkeys of a flock with a high natural occurrence of the disease were detected by using the Rous sarcoma virus as antigen in the complement fixation test. These and other studies in progress point to a successful development of reagents and procedures for the complement fixation test which can be successfully used with chicken serums for the detection and assay of leukosis antibodies. (AH e6-17)

During the past year the indirect tissue culture method of detecting and assaying lymphomatosis virus has been tested further. This method depends upon the activity of a resistance inducing factor (RIF) to inhibit the formation of micro tumor foci in chicken embryo fibroblast cultures. By this method a virus preparation of strain RPL 12 has been assayed and found to have a titer of $10^{8.3}$ RI units per ml. This

agrees very well with the titer obtained by chicken inoculations. Preparations of other virus strains, and field isolates have been similarly assayed and related to chicken inoculation assays. The titer of lymphomatosis antibodies in sera from several sources have been determined by the RIF method and by the usual chicken inoculation procedure. In almost all of these determinations there was good agreement in the titers obtained by the two methods. These results have provided good evidence that the tissue culture method based on RIF activity is a valid one for the detection and assay of the virus(es) causing visceral lymphomatosis. (AH e6-24, pending)

B. Improvement through genetic methods

Further studies confirm that a large proportion of the genetic variability in response to inoculation with Rous sarcoma virus is controlled by a single recessive gene for resistance. Preliminary studies indicate that the relationship between genetic resistance to induced erythroblastosis and induced lymphomatosis is not a simple one. Artificial exposure does not produce a consistent increase in incidence of lymphomatosis in some lines of chickens. (AH e6-2)

Methods have been developed for studying genetic variability within the inbred lines using skin grafting and related techniques. Preliminary results indicate that some of the lines are relatively uniform for genes controlling major histocompatibility differences. (AH e6-28)

C. Improvement Through Vaccination, Feeding and Management Practices

Studies on the relationship of cod liver oil in the diet to the incidence of avian leukosis tend to implicate certain sources of the cod liver oil. Further work is necessary before definite conclusions can be drawn as to the importance of the relationship indicated. (AH e6-21(C))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Studies of the Causative Agent of Avian Lymphomatosis

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PRODUCTION INFLUENCES ON ANIMAL PRODUCTS
Animal Husbandry Research Division, ARS

Problem. Pork, beef and lamb meat are excellent protein foods and most American diets are built around them. However, these meats are each criticized by the consumer for too much fat covering, lack of a bright red color, tenderness and flavor. The choice cuts and kind of meat are directly reflected in the demand and in the price of the product. Similarly, milk, eggs, poultry meat, wool and fur are demanded by the public in a high relationship to the desirability of their traits whether they be nutritive or functional. Many of the production practices directly affect the characteristics of animal products. Breed differences in butterfat and color of milk, nutritional effects on color of egg yolk, environmental stress on strength of wool, castration effects on flavor, color and tenderness of meat are well known production influences on animal products. Many other effects of production practices, however, are not so well understood but may be of considerable economic importance. Effective measures of evaluating quality and quantity differences are very important parts of this effort.

USDA PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will aid in livestock production. Research on beef, veal, lamb and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. Research on humane slaughter was initiated to develop information and techniques on preslaughter handling, restraining, immobilizing, and dispatching of hogs, cattle, and sheep, in order to determine the most effective procedures for meeting the requirements of the humane slaughtering law and the influence of the effect of these procedures on the quality of the meat. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; and in cooperation with eight State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the

Human Nutrition Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 16.4 professional man-years. Of this number 5.4 are devoted to beef, 1.3 to lamb, mutton, and chevon, 4.0 to pork, 1.0 to poultry and eggs, 1.7 to wool, fur, and fiber, 1.6 to humane slaughter, and 1.4 to program leadership.

Contract studies were completed during the year with the State Experiment Stations of Nebraska and South Dakota. The work in Nebraska was initiated to study relationships of certain live animal and carcass characteristics. At South Dakota the studies estimated the genetic and phenotypic relationships of carcass characteristics, growth, and conformation traits. Each of these studies constituted funds equivalent to .1 professional man-years.

A contract is in progress with the Wyoming State Experiment Station regarding the evaluation of lamb carcasses. Funds supporting this contract amount to .2 professional man-years.

A grant with the Polish Academy of Sciences in Poland provides for studies on the color of pork as influenced by heredity, sex, age, feeding, and management. Its duration is for five years (1960-1964) and involves PL 480 funds with \$42,784 equivalent in Polish zlotys.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations reported a total of 17.9 professional man-years of which 7.7 are on studies relating to beef, 3.1 lamb, mutton, and chevon, 2.8 pork, and 4.3 poultry and eggs. Comparisons are being made of grass fattening, drylot fattening, or combinations of these, as influences on carcasses and meat characteristics. Studies are being conducted on varying the length of heavy silage feeding preceding finishing with a high energy ration, creep feeding versus no creep feeding during the nursing period, and various combinations of ration ingredients with and without adjuvants. Research is in progress on the influence of ratios of protein to energy and total feed consumption on carcass characteristics of swine. Still other studies are on the evaluation of various criteria of selection for superior meat type swine. Research on egg quality includes work on the causes and prevention of blood and meat spots and undesirable yolk coloration. The effects of different egg washing techniques on interior quality are also being evaluated. Studies have been undertaken on the effect of nutrition and management on chicken and turkey carcass traits, such as skin pigmentation and a desirable amount of fat. A number of breeding projects contributing to regional research projects are designed to determine the effectiveness of selection and improving carcass

traits and the effect which selection of one carcass trait has on other carcass traits. Several stations are studying the pattern of growth in different breeds and crosses of sheep as affected by feed, sex, castration, and type of birth.

The activity by industry in the field of animal products is generally in the field of product processing and marketing. There are a few studies regarding the influence of production practices on product characteristics. One of the larger packing companies is carrying out an extensive beef improvement program including evaluation of carcasses for production of muscling, absence of waste, desirable ratio of fat to lean, and tenderness. Also, the packing industry cooperates extensively with publicly supported experiment stations in the grading and evaluation of carcasses resulting from various nutrition and management studies. Several textile mills conduct work on wool traits in sheep, including clean yield, fiber diameter and fiber strength. The number of professional man-years involved in industry effort on this area is estimated as 4.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Poultry and Eggs.

Preliminary studies are in progress on the colloidal properties of egg yolk. Through microscopic observations of the emulsified material of the egg yolk, it was found that by dilution of the yolk material with neutral salt solutions and careful filtering, it was possible to remove the emulsion. It is planned to determine the lipid composition of the emulsion and the lipid protein interrelationships in the non-emulsified portion of the yolk material by neutral salt precipitation. (AH e4-10).

INFECTIOUS AND NON-INFECTIOUS DISEASES OF POULTRY
Animal Disease and Parasite Research Division, ARS

Problem. Annual losses from infectious and non-infectious diseases of poultry, exclusive of parasitisms, are estimated to be at least \$200 million. Continued and expanded basic and applied research are essential to aid in reducing these losses, which inevitably affect cost to the consumer. Added to the initial losses from mortality, reduced weight gains, poor feed utilization, decreased egg production and lowered quality are the final losses occasioned by condemnations at dressing plants. Since institution of compulsory inspection for interstate movement of poultry and poultry products, overall condemnations because of disease have skyrocketed. The problem is to keep abreast of changing conditions in the field, which present increasingly complex problems requiring basic information.

USDA PROGRAM

The Department has a long-term program involving biochemists, microbiologists, pathologists, and veterinarians engaged in both basic studies and the application of known principles to the solution of infectious and non-infectious diseases of poultry. Research is being conducted on the diseases at the following locations.

The Federal scientific effort devoted to research in this area totals 31.4 professional man-years. This effort is applied as follows:

Ornithosis 5.1 at the National Animal Disease Laboratory, Ames, Iowa, and under cooperative agreements with the Universities of California and Minnesota, and the Agricultural Experiment Stations of Oregon and Texas.

Salmonellosis 3.0 at the National Animal Disease Laboratory, Ames, Iowa.

Pasteurellosis 2.0 at the National Animal Disease Laboratory, Ames, Iowa.

Chronic Respiratory Disease Complex 16.7 at the National Animal Disease Laboratory, Ames, Iowa, the Southeast Poultry Research Laboratory, Athens, Georgia, and under cooperative agreements with the Agricultural Experiment Stations of Connecticut, Delaware, Georgia, Maryland, Massachusetts, New York, North Carolina, Texas, Virginia and Wisconsin, and with the University of Minnesota. A basic project on chronic respiratory disease is in progress at the Hebrew University, Jerusalem, Israel, under a P.L. 480 Grant with funds equivalent to \$29,189 over a 3-year period.

Newcastle Disease 4.2 at the National Animal Disease Laboratory, Ames, Iowa, the Southeast Poultry Research Laboratory, Athens, Georgia, and under cooperative agreements with the University of Maine and the Wisconsin Agricultural Experiment Station.

Bluecomb 0.1 under contract with the University of Minnesota, St. Paul.

Leukosis 0.3 under cooperative agreement with the Regional Poultry Research Laboratory, USDA, East Lansing, Michigan.

Foot-and-Mouth and Other Exotic Diseases of Poultry 1.0 at the Plum Island Animal Disease Laboratory.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 58.6 professional man-years divided among subheadings as follows: Ornithosis 1.7; Salmonellosis 3.0; Chronic Respiratory Disease Complex 20.1; Newcastle disease 4.9; Infectious Bronchitis and Laryngotracheitis 2.4; Other diseases (hepatitis-synovitis syndrome, avian encephalomyelitis, aortic rupture, leucosis, staphylococcosis) 26.5.

Industry and Other Organizations are conducting studies to determine the efficacy of the pharmaceutical and biological products in the control of poultry diseases. Basic research on the various causative agents of poultry diseases has normally been completed essentially before these companies obtain the disease agents and undertake studies in relation to their respective products. Their objectives are two-fold - to aid in poultry disease control and to make a profit from their business. A number of these companies make grants to State Universities. A considerable number of National and State poultry organizations support research on poultry diseases through grants to State Universities and Experiment Stations.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Ornithosis

In 1961-62, the recently opened facility at the National Animal Disease Laboratory, Ames, Iowa, did not become suitable for conducting investigations on this highly dangerous disease of man, turkeys, and psittacine birds.

In 1961, in cooperative work with the University of California at Davis, a bacterium (*Herrellae* species) of low pathogenicity for humans was found to yield a soluble antigen which fixed complement in the presence of antibodies to ornithosis. The bacterium yield identical titers in human sera by the DCF test. The bacterial antigen had a high degree of correlation in detecting ornithosis antibodies in over 100 turkey sera. The soluble antigen was extracted from the *Herrellae* bacteria by boiling for 2 or more hours. It was extracted with acetone and ether from a boiled culture of the organism but could not be obtained from the raw bacterial suspension. Absorption experiments indicated that the antigenic components of the ornithosis agent is composed of substances common to ornithosis and the *Herrellae* bacteria.

In 1962 at the University of California laboratory, human serums of subjects suspected of having ornithosis or lymphogranuloma venereum were tested with the ornithosis and the Herellea-like bacterial (BA-16) antigens. Serums having high titers with the Texas ornithosis antigen also reacted with an antigen prepared from the bacterium.

A comparative study between the BA-16 strain of Herellea and three additional strains of Bacterium anitratum shows that there are antigenic differences to anti-ornithosis and anti-Herellea serums. One strain of B. anitratum which differed biochemically from the Herellea bacteria showed no cross-reaction with anti-ornithosis and anti-Herellea serums.

The Herellea-like strain of bacteria are highly pathogenic for guinea pigs when inoculated intraperitoneally and for chicken embryonating eggs, but was not pathogenic for turkeys. High titer complement fixing antibody serums could be prepared in turkeys following hyperimmunization.

A mouse-lung cell culture has been carried through 25 generations. The C-1 strain of ornithosis virus produced demonstrable elementary bodies and a cytopathogenic effect in the line cell in 24 to 48 hours that could not be demonstrated in the HeLa culture within 120 hours.

In 1961, in cooperation with the University of Minnesota, epidemiological studies revealed that the ornithosis agent was widespread in turkey flocks in some north central States. Examinations of sparrows in areas where the disease is enzootic failed to incriminate these birds as reservoirs of the agent. No virus isolations were made from turkey flocks showing serological evidence of ornithosis. The development of the DCF test for ornithosis has made available a practical diagnosis procedure in the study of this disease. Chlortetracycline proved effective in treatment of breeder flocks.

In 1962 at the University of Minnesota, serological studies continued to show a number of north central States have turkey breeder flocks showing ornithosis infection (6% to 23% of the flocks tested). The infection is of low virulence and no outbreaks have occurred, nor have virus isolations been made. Search for a reservoir of the agent has not been successful. Basic studies have been conducted to improve, simplify, and make the direct complement fixation diagnostic test more specific. Antibiotic treatment failed to show a direct effect on the diagnostic response of infected turkeys as compared to uninfected turkeys.

In 1961, cooperative work with the Oregon Experiment Station on natural reservoirs of the ornithosis agent failed to show that gulls and other free-flying birds were carriers of the agent in areas where the disease had broken out in turkey flocks sporadically for several years (1401 specimens were examined). Studies with earthworms failed to reveal them as probable virus reservoirs of the agent, even on infected premises. Susceptible turkeys did not develop infection when placed on contaminated litter. Infection was transmitted from clinically ill to susceptible turkeys through litter contact but not by aerosol.

In 1962, at the Oregon Station, six ornithosis isolates from turkeys, chickens, and sea gulls were studied in relation to their antigenic and pathogenic characteristics. The isolate from the sea gull was the most toxic for turkeys and produced mortality and severe lesions. One of the agents of chicken origin was the least toxic and apparently was incapable of infecting turkeys by the intramuscular route. This isolate would infect turkeys when inoculated into the air sacs, but it did not produce mortality.

The antigenicity of each strain in relation to turkeys was determined at 21 days post-inoculation based on the serological response to the indirect complement fixation test. The highest antigenic response was obtained with the gull strain of virus.

A transitory reaction to Mycoplasma gallisepticum-agglutinating antigen was produced in turkeys inoculated with ornithosis-infected mouse tissue. Experimental indirect complement-fixation (ICF) and agglutinating antigens were produced with the standard ornithosis viruses. The antigens were low antigenically and not satisfactory for the ICF test. The agglutinating antigens were too sensitive and gave a high percentage of false positive reactions.

In 1961, in cooperation with the Texas Agricultural Experiment Station, the histopathology of calves infected with the virulent and mild strains of ornithosis were studied. The lesions of the virulent strain were similar to those of sporadic bovine encephalomyelitis, whereas the mild strain produced no lesions.

A calf was used to produce antibodies for the complement-fixation (CF) diagnostic test to solve the problem of a source of positive serum. Turkey flocks were surveyed for infection and one flock detected. Virus was isolated from this flock.

Drug dosage was found not as important as time of therapy. Preliminary work shows that tylosin is an effective drug against ornithosis. Under experimental conditions 2 grams of tylosin per gallon of drinking water for 7 days was ineffective in ridding turkeys of the ornithosis agent, but 0.25 grams of tylosin per gallon of drinking water, administered for 3 weeks, was effective in removing the ornithosis agent from infected turkeys.

DNA derivatives, but not RNA derivatives, have the ability of overcoming the effect of aureomycin in tissue culture systems.

Adult sea gulls and sparrows were infected to determine their ability as potential reservoirs. Neither of these species developed the carrier state. Thirty-nine species of wild birds representing 278 blood samples were collected and tested for evidence of antibodies. One Foster tern had sufficient reaction to indicate previous infection.

In 1962, at the Texas Station, continued research revealed the agent of ornithosis caused abortion in 7 pregnant ewes and death in 2 non-pregnant ewes. Pigs were refractory to the agent of ornithosis when inoculated by various routes. The agent of ovine virus abortion caused some low serologic titer rises in turkeys but no lesions or signs, and virus was not isolated. Fractionization study of positive turkey sera shows the antibody to be of high molecular weight. There is an apparent difference between the ICF, Benedict DCF, and Broomfield DCF tests in the antibody measured.

DNA was effective in overcoming the effect of chlortetracycline but certain derivations or combinations of derivatives were only partially effective. Virus was not isolated from turkey eggs collected after inoculation of turkey hens with a mild strain (Minnesota) of ornithosis.

B. Salmonellosis

In 1961-62 at the National Animal Disease Laboratory, Ames, Iowa, insufficient staff and equipment precluded accomplishment of progress for a report.

C. Pasteurellosis

In 1961, at the National Animal Disease Laboratory, Ames, Iowa, research on this disease resulted in the following findings: A killed fowl cholera vaccine that had maintained a high degree of immunity for 1 year in chickens raised under experimental conditions, failed to prevent an outbreak of acute fowl cholera in turkeys raised under field conditions. Studies showed immunogenic differences between the vaccine strain of *Pasteurella multocida* and the strain isolated from the turkeys. A vaccine prepared with one type did not stimulate immunity against the other. A bivalent emulsified killed vaccine gave good protection in chickens for 37 weeks (duration of test) against both types. A bivalent, aluminum hydroxide adsorbed killed vaccine did not give satisfactory protection.

Serological tests showed that the two strains were different serotypes (Little and Lyons' classification). Serotype 1 fermented dulcitol but not xylose and was virulent for 16 and 45-week-old chickens. Serotype 3 fermented xylose but not dulcitol and was virulent for 16-week-old turkeys and 45-week-old chickens. However, 16-week-old chickens were more resistant to this type.

The biochemical and serological characteristics of 84 strains of *P. multocida* from 17 different States and the District of Columbia were similar to either strain X-73 or P-1059.

In 1962, at the National Animal Disease Laboratory, investigations of this widespread poultry disease gave the following results: 1) Passive immunity tests in mice, using hypered immune rabbit serums, did not differentiate between the two different immunogenic strains of *P. multocida* associated with fowl cholera. Therefore, the passive immunity test, which is often used to classify *P. multocida*, is of questionable value since it does not differentiate between these two immunogenic antigens. 2) Active immunity tests in mice, using an

emulsified vaccine, did not stimulate antibody production in mice to the degree that mice could be substituted for chickens when testing efficacy of emulsified fowl cholera vaccines. 3) Different strains of P. multocida of the same antigenic type can produce different pathology in chickens. One strain produced an acute septicemia, whereas another strain produced facial swelling and respiratory lesions. However, the septicemic strain when used in a vaccine prevented both types of disease. 4) In efforts to characterize antigenic components of related strains of P. multocida and to determine the chemical basis of virulence, host specificity and immunogenicity, hyperimmune rabbit serum and P. multocida antigen were produced from 3 different strains of P. multocida.

D. Chronic Respiratory Disease-Complex.

In 1961, at the National Animal Disease Laboratory, Ames, Iowa, research on this disease of poultry was begun late in the year - about July 1 - and the following report is for that period through June 30, 1962.

In 1962, at this Laboratory, results thus far show that all lyophilized cultures were viable after three years. Two strains were completely killed after freezing and thawing 5 and 7 times, whereas most strains survived the freezing and thawing 12 to 15 times. Only a few strains survived freezing and thawing 20 times. Cultures stored at -65°C showed a decrease of about 50 to 65 percent in viable count after one month. All cultures stored at -30°C survived 12 to 18 months. The cultures stored at 5°C survived from 20 to 60 days depending on the strain.

It has been observed that 0.85% sodium chloride solution is rapidly toxic to all strains of PPLO. The NaCl appeared to be equally toxic to 24-, 48-, and 72-hour cultures of the same strain. Buffering the saline solution with 0.02 N sodium phosphate reduced the toxicity. The addition of 1 ml. of growth medium to a liter of saline solution reduced the toxicity to three strains of non-pathogenic PPLO but enhanced the toxicity to two strains isolated from chickens affected with CRD.

The PPLO strains under study were purified to eliminate the possibility that bacterial cells may have been carried along in a dormant form in the PPLO cultures. Experiments to derive bacterial forms by culturing the PPLO in media at various pH levels, in media containing sub-optimal amounts of horse serum, and in medium containing no horse serum, were unsuccessful. In medium containing 5 percent yeast extract, however, two of seven PPLO strains showed bacterial cells in the 3rd and 5th transfers, respectively, and two others showed changes on solid medium in which the characteristics typical of PPLO were lost and the colonies appeared to be tiny bacterial colonies. Smears from these colonies, however, showed no bacterial cells.

Microbiological examination of turkeys showing signs of airsacculitis infections and sinusitis resulted in the isolation of Mycoplasma, Pasteurella multocida, and Escherichia coli. This re-emphasizes the importance of studying airsacculitis as a disease complex rather than as a specific disease entity.

Gross examinations of turkeys experimentally infected with Pasteurella multocida revealed lesions indistinguishable from those often observed in field cases of airsacculitis. This indicates the need for study of the lesions produced by certain strains of P. multocida and a comparison of these lesions with those produced by other agents and by combinations of agents associated with the airsacculitis complex.

In 1961, personnel at the Animal Disease and Parasite Research Division's Southeast Poultry Research Laboratory, Athens, Georgia, began work in June in facilities of the Georgia Poultry Disease Research Laboratory at Athens. (Construction of the Division's laboratory began in April.) Accomplishments are combined with the 1962 report.

In 1962, research at this Laboratory include 1) Development of a method for preparation of M. gallisepticum (FPLO) diagnostic antigen; 2) Successful hyperimmunization of rabbits and chickens with M. gallisepticum for a source of specific antiserum; 3) Initiated field studies with several large commercial chicken growers to compare liveability, feed conversion, and other health factors in broilers from parents free of M. gallisepticum; 4) conducted basic studies on infectious bronchitis and Newcastle disease viruses, important complicating etiologic agents of the CRD syndrome.

In 1961, in cooperative research with the Agricultural Experiment Station of Connecticut, it was found that pathogenic cultures of the chronic respiratory disease agent, FPLO, placed on cardboard and eggshells failed to survive 48 hours at temperatures of 4°C, 25°C, and 37°C. Coliform organisms, closely associated with air sac infection in chickens, showed a wide variation in their virulence for chickens, and to belong to different serologic types within the pathogenic group.

Pleuropneumonia-like organism (PPLo) antigen for the diagnosis of the disease in chickens was not suitable for use in turkeys. Very high levels of antibiotics were necessary for control of CRD in chickens (1000 grams per ton of feed). Immunization of replacement stock at a young age (6 weeks) by intranasal exposure to pathogenic Mycoplasma gallisepticum (FPLO) seems promising. An antigen for FPLO diagnosis in chickens is now produced on a commercial basis.

In 1962, the Connecticut Station produced and distributed FPLO chicken antigen for testing chicken whole blood or serum for antibodies to Mycoplasma gallisepticum to 24 Stations and 11 countries. A survey of the incidence of flock infection to FPLO indicates a high rate of flock infection in Connecticut.

Production of a breeder flock of 14,000 chickens from FPLO-infected parents has been accomplished by testing with FPLO antigen, removal of infected hens, and practicing rigid security management. Antibiotic therapy of FPLO-infected birds stressed by other respiratory infections, seemed to favor use of combinations of antibiotics over one at a time. Active immunization studies with living FPLO are continuing.

In 1961, cooperative work with the Delaware Agricultural Experiment Station yielded these interesting results: 1) The amount of antibiotic entering a warm egg from a cool dip solution is dependent among other things upon concentration of antibiotic in the dip solution. Concentration of 600 and 800 ppm of erythromycin were superior to 400 ppm both in amounts and number of eggs showing antibiotic activity. 2) Of several new drugs tested, none proved to be superior to tetracycline antibiotics fed as potentiated diets. The antibiotic, aureomycin, was not detected in eggs from chickens receiving 200 and 400 gram levels of antibiotic in the feed but was present in eggs when the level was raised to 1,000 or more grams per ton. 3) The USDA Killed Newcastle Disease vaccine gave 91% and 77% protection against challenge with the GB strain as compared to 20% and 19% protection afforded by the B-1 strain of vaccine. Compared to a tissue culture living vaccine, its use in broiler flocks resulted in less condemnations from air sac infection at slaughter.

In 1962, the Delaware Station studied the mechanics of treating hatching eggs with antibiotics for the control of ovarian transmission of PPLO. Various factors, including concentration and form of drug, temperature differential, time in solution, and influence of additives, have been studied to determine their influence on the egg dipping process. The results obtained provide fundamental information for the practical application of this procedure. Investigations of other methods of treating hatching eggs have been conducted and the results indicate that spraying of eggs is not satisfactory, while the application of vacuum or a combination of vacuum and spraying offers an additional means of treatment.

Contamination of eggs with organisms not susceptible to the drugs used in the treatment process is a constant problem and constitutes a major deterrent to practical use of these methods of control. Several new compounds, screened for their efficacy in treating experimental air-sac infection, failed to show superior results to those obtained with the tetracycline antibiotics potentiated by low calcium diets.

In 1961, cooperative work at the Georgia Agricultural Experiment Station on technics for diagnosis of PPLO and factors influencing the course of the disease, showed that the fluorescent antibody technic was not practical for diagnostic purposes. The hemagglutinating activity of pathogenic avian mycoplasma apparently is located in an acetone soluble fraction of the cell membrane. Experimental PPLO and E. coli infections do not directly influence vitamin A metabolism in the chick. Vitamin A levels in the ration do not affect the course of PPLO or E. coli infections in the chick except in severe avitaminosis.

Critical surveys in several broiler-producing areas have definitely established that variations in management and environmental factors, together with the use of live virus poultry vaccines, or concurrent natural outbreaks of other diseases, greatly influence the incidence and severity of air sac infection in chickens and the subsequent increase in condemnations when these birds are slaughtered for food.

In 1962 the Georgia Station conducted critical studies on the prophylactic and therapeutic value of antibiotics for prevention and treatment of CRD. Tylosin water medication of breeder flocks did not favorably influence the incidence of air sac lesions. Although injection of 10 mg. gallimycin or dihydrostreptomycin into day-old commercial broiler chicks as a preventative medication appeared to have some beneficial effects, in the main it did not justify labor and medication costs. Low levels of toxic fat ingredient (20%) fed to broilers for the first 6 weeks, as well as for the full production period 9 weeks) markedly influenced the condemnation rate due to severe air sac disease without invoking a clinically recognizable form of the disease. An extensive field study on the effect of preventive medication of broilers with furazolidone or chlortetracycline revealed a slight difference in favor of chlortetracycline in regards to mortality, feed conversion, condemnations, cost of medication and cost of production per pound.

In 1961, at the Maryland Agricultural Experiment Station, cooperative experimental research was conducted on growth requirements and serological classification of pathogenic M. gallisepticum (FPLO). This basic work afforded a sound approach to field problems.

In 1962 at the Maryland Station, work on experimental FPLO diagnostic antigens showed a prevalence of certain serologic types of FPLO in the State, differing somewhat from the types found in most States.

In 1961, at the Massachusetts Agricultural Experiment Station, cooperative research on CRD was conducted on several phases of the problem in chickens with the following results:

Cultural studies: Fermentation reactions can be used to separate the avian FPLO into two groups - fermenters and nonfermenters. Members within the fermenting group did not ferment the same carbohydrates. Further differentiation on the basis of carbohydrate fermentation was not regarded as reliable.

Transmission studies: Transmission of CRD to susceptible birds by contact exposure with premises previously occupied by CRD-infected birds was not successful in the single experiment that was conducted.

Serological studies: Studies of 19 avian FPLO were done in two phases. In the first phase, antiserums were obtained from rabbits after 6 to 10 inoculations and the tube agglutination test was used to classify the FPLO. The results showed that the FPLO fell into eight serotypes.

In the second phase of these studies, antiserums which would inhibit growth of the homologous FPLO (several strains required as many as 40 inoculations) were produced. The slide agglutination test was found to be of no value for classifying the FPLO. The tube agglutination and the growth inhibition tests were acceptable but neither alone was completely reliable. In these studies, seven serotypes were encountered and found to be related.

Response of CRD to medication. In four trials conducted in 6 to 7-week-old chickens, the value of chlortetracycline and oxytetracycline incorporated in low calcium diets was determined for the control of experimental CRD complicated with E. coli. Noninfected birds made the most favorable weight gains. The poorest weight gains were made by the infected-untreated groups. The infected-untreated groups also revealed more extensive and more severe involvement in the air sacs than did the treated groups. Medication did not appear to reduce the agglutinin response or the recovery rate of the agent from the trachea.

Control and eradication of CRD: a) Antibiotic egg dipping. Investigations to determine the effectiveness of destroying the CRD agent in the egg by dipping in erythromycin solution have indicated that bactericidal activity is observed within certain limits. b) Testing of flocks. The identification of CRD-free flocks with the serum-plate agglutination test and the establishment of additional flocks with progeny from negative flocks appear promising.

In 1962, the Massachusetts Station continued the investigations and reported these results:

Properties of the agent (viability studies): The viability of two strains of Mycoplasma gallisepticum (Hy and S6) is influenced markedly by temperature and the nature and quantity of materials in which the PFLO are suspended. In the various materials tested at temperatures above 0 C, the viability varied from 1 day to 120 days; at -20 C the PFLO were maintained for many months.

Transmission studies: Transmission of CRD to susceptible birds by contact exposure with premises previously occupied by CRD-infected birds was not successful. Two-year-old hens that had undergone a natural outbreak of the disease at an early age did not transmit the disease to susceptible birds by cohabitation or aerosol. Birds with active respiratory signs following experimental CRD-inoculation transmitted the disease to susceptible chickens by direct contact while transmission by aerosol was not successful.

Serology and immunity: Turkeys and chickens vaccinated with erysipelas bacterin produced a transient nonspecific serological response to PFLO serum-plate antigen. Marked resistance to challenge inoculation with a highly pathogenic CRD strain was demonstrated in chickens that have survived a natural outbreak of CRD. A satisfactory immune status was not produced in chickens by vaccination with an attenuated CRD strain.

Response of CRD to medication: The performance of chickens experimentally inoculated with CRD and E. coli followed by therapy with chlortetracycline and oxytetracycline, alone or in combination, potentiated by a low calcium diet, was superior to that of infected-nontreated chickens.

Control and eradication: CRD-free stock can be reproduced and maintained if adequate sanitation and management practices are observed.

In 1961 cooperative work at the University of Minnesota on Mycoplasma gallisepticum (PPLO) infection of poultry was directed to the disease in turkeys and resulted in these findings: 1) Field investigations strengthened the idea that airsacculitis is caused by a multiplicity of conditions, but infectious sinusitis does play a major role in its cause. 2) Studies tend to indicate that temperature and humidity may play a role in increasing the incidence of airsacculitis in a turkey flock. 3) A method for the production of an S_6 type of PPLO diagnostic antigen in large quantities was developed. 4) The Infectious Sinusitis Control Program was intensified by shifting to a 100% test and placing more stringent controls on the hatcheries and growers.

In 1962, at the University of Minnesota, studies were continued on the problem of PPLO in turkeys with the following results: 1) a satisfactory serum plate antigen has been produced in sufficient quantities to be available for an extensive pilot control program. 2) The serum plate, tube agglutination and HI tests gave comparable results as flock detection tests for infectious sinusitis. 3) The classification of PPLO isolates from turkeys on the basis of serological, pathological, and biological characteristics has been helpful in determining the role of various PPLO serotypes in airsacculitis. 4) Field investigations of farms experiencing excessive condemnations from airsacculitis indicated that infectious sinusitis was the major cause of high condemnations. 5) Air sac lesions in day-old poults appears to be a very common problem, and the role of "N" strain of mycoplasma in causing this problem is under investigation. 6) Investigations on a fryer-roaster turkey farm indicate the incidence of air sac lesions of both interclavicular and abdominal air sacs may be high, but condemnations may be low. The role of the "N" strain and other micro-organisms in producing this residual exudate is under investigation. 7) The intensified breeder flock inspection program and experimental infectious sinusitis control program has involved over 700 breeder flocks. The results indicate a very low incidence of the S_6 type in the breeder flocks. The progeny from these flocks are being critically followed during the growing period. Seven flocks have been examined from start to slaughter. The condemnation rate in these flocks has been extremely low, but the incidence of air sac lesions of both interclavicular and abdominal air sacs has been extremely high. A variety of organisms have been isolated, such as E. coli, aspergillus, Pasteurella, Salmonella.

In 1961, at the New York Agricultural Experiment Station, cooperative research was directed toward technics to prevent egg transmission of PPLO. Studies showed that dipping PPLO-infected eggs in erythromycin solutions - 400 to 1500 parts/million, reduced but did not eliminate the infection under experimental conditions. Under commercial conditions, 900 parts/million as a dip, without pre-warming the eggs, markedly reduced the condemnation rate and yielded significantly fewer serologically positive birds at 9½ weeks. Under experimental conditions, tylosin was superior to erythromycin as a dip solution for eggs infected with PPLO (S_6).

Subcutaneous injections of 25 and 5 mg of erythromycin and feeding of 350 gms aureomycin/ton with low calcium, lowered the egg transmission rate of PPLO infected hens. Complete elimination of the transmissions did not take place. Non-treated hens transmit PPLO through the egg to a decreasing extent as time passes.

Typical lesions of complicated CRD seen in field outbreaks were reproduced in the laboratory by the intratracheal inoculation of PPLO culture (S₆), E. coli (pathogenic Virginia strains) and infectious bronchitis virus. For the most severe effect, the presence of PPLO was necessary with any combination of agents.

The prophylactic effect of serpasil, neomycin, furaltadone plus potentiated aureomycin, sulfalthoxypyrazine alone and with potentiated aureomycin was tested on birds inoculated with the combination of agents designed to produce complicated CRD. The last named drug combined with potentiated aureomycin gave excellent results.

Laboratory media adapted strains cannot be relied on to test efficiency of media for primary isolation of PPLO from tissues. Studies show, however, that fermentation reactions can be used to separate the avian PPLO into two groups, fermenters and nonfermenters. Members within the fermenting group did not ferment the same carbohydrates. Further differentiation on the basis of carbohydrate fermentation was not regarded as reliable.

In 1962, the New York Station continued the work on M. gallisepticum (PPLO) infection with these results:

A comparison of seven media for primary isolation of PPLO from chicken tracheas with a procedure involving preliminary enrichment in yolk sacs showed no marked superiority of one over the other.

Twelve distinct serotypes of avian PPLO have been determined by the colony inhibition technique of Edward.

Six sulfonamides combined with 500 grams per ton chlortetracycline and 0.5% terephthalic acid were screened for therapeutic effect against experimentally produced CRD. Two compounds gave best results - sulfaethoxypyridazine 0.0125% and sulfasoxazole 1.0% in the feed. Delaying medication of birds after infecting them reduced the efficiency of these compounds inversely in relation to the length of time of the delay. Benefit to contact-exposed birds was derived from medication but again delay of medication for longer than 2 days reduced or eliminated the therapeutic effect.

Dipping of chicken hatching eggs experimentally and naturally infected with Mycoplasma gallisepticum in concentrations of Tylosin over 800 parts per million for 5 to 10 minutes was highly effective in eliminating the infection.

Treatment of PPLO shedder hens with 15 mg. per corten had no effect on the transmission rate of PPLO in the egg.

Young chickens inoculated in the air sacs with relatively pathogenic strains of Mycoplasma gallisepticum did not shed PPLO into their eggs after a challenge inoculation when they came into production. Chickens inoculated with a mild pathogenic strain yielded 11% infected eggs. A control group produced 19% infected eggs.

In 1961 cooperative research with the North Carolina Agricultural Experiment Station was of a basic nature to determine antibacterial and antiviral activity of chicken serum. The susceptibility of fowl to E. coli inoculations were explored in an effort to more specifically determine the changes occurring following infectious bronchitis virus inoculation. Antibacterial activity of serum was studied relative to bronchitis inoculation to determine possible influence of bronchitis on susceptibility of E. coli inoculation using the colorimetric method reported last year. This work is important in arriving at a better understanding of host defense mechanisms.

In 1962, cooperative research at the North Carolina Station on the defensive values of normal chicken serum for pathogenic microorganisms (E. coli) resulted in the development of a simplified procedure for electrometrically determining anti-E. coli activity of chicken serum. This test was employed in two experiments designed to determine the changes occurring in anti-E. coli activity of sera from young chickens inoculated with infectious bronchitis virus. A measurable reduction in anti-E. coli activity was observed in sera from birds inoculated with IBV, when compared with sera from non-inoculated, isolated controls. Observed changes closely coincide with results obtained in previous experiments employing in vivo challenges with E. coli.

Very critical histological studies indicate that the presence or absence of lymphofollicular lesions in the sinuses, tracheas, lungs and air sacs of turkeys which have been inoculated via the infraorbital sinus with a PPLO isolate is not a reliable criterion on which to base a diagnosis of pathogenicity of the isolate.

In 1961 the Texas Agricultural Experiment Station conducted cooperative research on PPLO in poultry and results indicated the hemagglutination (HI) test to be a more accurate diagnostic tool than the serum plate (SP) test, in experimental eradication of infectious sinusitis of turkeys of 36 breeder flocks (38,324 birds). The antibiotic spiramycin-adipate was extremely effective in treating IS, but was of little value in treating airsacculitis of turkeys.

Variant types of M. gallisepticum (PPLO) were discovered during the year's work. The control of PPLO egg transmission by injection of hatching eggs with a combination of tylosin tartrate, 50 micrograms, and dihydrostreptomycin, 5 milligrams, proved not feasible because of greatly reduced hatchability.

In 1962 the Texas Station continued its cooperative investigations with the following results:

When M. gallisepticum infected eggs were dipped in chilled antibiotic solutions, egg transmitted infection was markedly reduced and broilers so produced remained relatively free of infection during the growing period. Condemnation losses were significantly reduced in birds produced from dipped eggs, and birds so produced outweighed controls by 0.23 pounds. Techniques were developed by which uniform M. gallisepticum plate and tube test antigen could be produced in a simplified medium. The serum plate diagnostic test for infectious sinusitis has been successfully used in eradication of the disease from many hatchery supply flocks.

In 1961, at the Virginia Agricultural Experiment Station, cooperative research on CRD was conducted on basic and applied facets of the problem with these results: 1) PPLO do not readily mutate to increased resistance to furazolidone, tetracycline or chloromycetin. 2) S-6 type PPLO are not physiologically identical, i.e., they are inhibited by different concentrations of glucose and produce different degrees of acidity from identical amounts of glucose. It is possible that one medium will not be suitable for the isolation of all S-6 type PPLO. 3) S-6 type PPLO produce distinctive breast blisters. 4) A "PPLO-free" flock has been maintained for 5 consecutive years through the use of good management practices. 5) Vaccine viruses will greatly increase the contact spread of PPLO and the severity of the lesions. 6) Pathogenic strains of E. coli were isolated from feed, but all the coliforms were destroyed by pelleting. 7) The duration of susceptibility of respiratory disease infected chickens to E. coli lasts about 50 days.

In 1962, the Virginia Station directed the cooperative research toward certain stress factors which affect CRD, and other related problems, with the following results: 1) M. gallisepticum produced an experimental salpingitis in 64% of individuals observed following yolk sac or air sac inoculation of day-old chicks. M. gallisepticum could be recovered from affected oviducts until after the flock was in egg production (25 weeks). 2) An improved formula for the medium to propagate M. gallisepticum has been developed. 3) A "PPLO-free" flock has been maintained for 6 consecutive years through good management practices. 4) Thirty-six percent of 518 immature chickens, vaccinated with live pathogenic M. gallisepticum, were protected against small challenge doses of the organism. Similar vaccination of birds kept for laying had no significant effect on egg production, hatchability, or progeny. Egg transmission of the agent was not detected. 5) Lesions suggestive of those produced by Mycoplasma gallisepticum were produced following the inoculation of the B₁ strain of Newcastle disease vaccine by the air sac or aerosol routes. 6) Increasing the concentration of toxic fat, but not salt, in the feed increased the incidence of coliform infection following intravenous inoculation. Toxic fat-fed chickens made a poor defensive reaction against air sac inoculated E. coli. Furaltadone, but not specific antiserum, protected toxic fat-fed birds from air sac or IV inoculated E. coli.

In 1961 at the Wisconsin Agricultural Experiment Station, starting in May of that year, cooperative research was begun on the problem of airsacculitis in turkeys. The multi-discipline research approach included studies of etiologic agents and the impact of agrometeorological factors. This research resulted in the following statements concerning 4 flocks of turkeys from hatching to slaughter. 1) Aairsacculitis is a major problem in the turkey-production area of wisconsin. 2) There apparently is no single etiological agent which causes the majority of airsacculitis in the study area. A number of infectious agents, some in the presence of certain stressors, have in the past been shown to be a possible contributing factor to avian air sac lesions. None of these can be ruled out, at present, as a contributing factor to airsacculitis in this area. 3) It can be said that, if the present means of isolation are sufficiently sensitive, airsacculitis can occur in the absence of heavy

persistent infections with mycoplasma, ornithosis virus, or bacteria. 4) The continuous high-level feeding of antibiotics may be encouraging persistence of certain atypical forms of bacteria in the tissues of the poults and actually put the birds at a disadvantage in the host-parasite relationship. An agro-meteorological station was designed and built to continually record on tape environmental conditions inside and outside the building. The building is a typical "pole" type of the area and will house 400 turkeys. Preliminary determinations of carbon monoxide, carbon dioxide, and ammonia concentrations have been made.

In 1961-62, the work on CRD under PL 480 grant to the Hebrew University, Israel, was of a preliminary educational nature to the investigators.

E. Newcastle Disease.

In 1961, at the National Animal Disease Laboratory, Ames, Iowa, research work was done on different killed Newcastle disease (ND) vaccines with respect to different ratios of Amphojel to the macerated virus material prepared from embryonated chicken eggs (ECE), replacement of the ECE virus material with normal embryonated chicken eggs or amnio-allantoic fluid, and comparison of inactivation of virus material before and after the addition of Amphojel. Under the conditions of the experiment, vaccines of low virus material content, except or less than .5%, with the proper amount of Amphojel, were equally effective as higher virus material content vaccines. Normal tissue vaccines had little if any potency. Amnio-allantoic fluid vaccine compared favorably with ECE virus tissue vaccines. Inactivation of virus material after the addition of Amphojel indicates that the immunogenicity of the vaccine was reduced significantly as compared with similar virus inactivated before the addition to Amphojel.

Direct complement fixation tests on chicken serums within 1 hour of collection tended to be more reliable than on those that had been collected for longer periods or on those stored at 4°C for several days.

In 1962, at the National Animal Disease Laboratory, in studies on Newcastle disease a chicken anti-sheep hemolysin was developed for the complement-fixation system. This made possible the conglutinating complement adsorption study of avian serums because chicken complement cannot be tested with rabbit anti-sheep hemolysin nor can guinea pig complement be titrated with chicken anti-sheep hemolysins.

The conglutinating complement adsorption test (CCAT) for avian (chicken and turkey) sera was successfully developed using Brucella and ornithosis antigens. Initial trials with Newcastle disease (ND) antigen were negative.

Experiments designed to measure the relationship of embryo killing time for ND virus and ND vaccine antigenicity are in progress. Ten vaccines were each prepared with virus from embryos inoculated with different serial ten-fold dilutions (10^{-1} to 10^{-10}). The embryo death time increased after the 10^{-5} dilution and was negative in the 10^{-10} dilution, but the virus from the dead

embryo fluids in each dilution had similar end point infectivity titers ($10^{-8.5}$) and hemagglutination (HA) titers (1280). The vaccines have been injected into birds for serological and virus challenge immunity tests.

Newcastle virus was successfully grown in tissue culture through 10 passages in primary chicken embryo fibroblasts, resulted in maximal egg infectivity titers of 10^7 and HA titers of 320.

ADP recommended, killed Newcastle disease virus (NDV) vaccines presently being used in the field contain 45% macerated embryonated chicken egg virus (ECEV) and 50% amphojel. Studies of NDV adsorption on amphojel ($\text{Al}(\text{OH})_3$) has shown that this ratio of amphojel to ECEV will adsorb less than 0.1 percent of the virus in the vaccine as measured by egg embryo infectivity tests. All live virus infectivity was not adsorbed at a ratio of 97.5% amphojel and 2.5% ECEV. A ratio of 80% amphojel and 20% ECEV was required to remove all the hemagglutination units from the centrifuged vaccine supernatant.

Elution studies of virus from amphojel vaccine by serial washings with equal parts phosphate buffered saline and ECEV saturated amphojel were made to simulate the release of virus from amphojel in vaccinated birds. Negative HA tests were obtained from serial washings of ECEV alone on the third wash, from amphojel saturated with ECEV virus on the 24th wash, and from amphojel saturated with allantoic fluid virus on the first 7 washings and again on the 90th wash. These results indicate a correlation between virus concentration and/or purity and duration of virus adsorption on amphojel. Quantitatively a very low percent (1-2%) of virus could be washed off of amphojel and detected by the HA testing system. Consequently, a more accurate method of testing washings for virus must be developed.

In 1961, in cooperative studies with the Wisconsin Agricultural Experiment Station, Madison, a Newcastle disease virus (NDV) repository was maintained, and characterization studies of a number of virus strains were conducted. Strains of NDV were distributed under federal permit to biological houses and research institutions. The development of technics for diagnosis and characterization of NDV by various methods under varying circumstances is continuing.

In 1962, at the Wisconsin Station, an assay method for characterization of NDV was developed. It is sensitive and dependable, and is based on the ability of NDV to form plaques in a primary cell tissue culture growth medium. Factors affecting kinetics of growth and genetic markers by the use of inhibitors are being studied for their value in differentiation of NDV strains. It was found that NDV strains from Mexico, Mexico-MU, and Mexico-Sonora, are not as readily neutralized by antisera to B1, one of the standard vaccine strains. It takes a thousand times as much B. antiserum to neutralize the heterologous Mexican strains as it does to neutralize the homologous strain. The staff of the repository have assumed responsibility for planning a symposium on "Newcastle Disease Virus as an Evolving Pathogen." The purpose of the symposium is to achieve a better perspective of the research on the virus of Newcastle disease as a strain-complex.

In 1961-1962, at the University of Maine, Orono, a cooperative experimental field study on Newcastle disease was begun. The purpose was to determine the efficacy of a killed ND vaccine in controlling and eradicating the disease in a large breeder and broiler growing area, and to determine the effect of such a ND vaccination program on the incidence and severity of air sac infection. To date approximately 6.2 million doses of dead ADP type Newcastle disease vaccine has been used in the State of Maine with no known outbreaks of ND in vaccinated flocks. A natural outbreak in a broiler flock of ND was counteracted in the succeeding two flocks by vaccination with dead ND vaccine with no further trouble. The incidence and severity of air sac infection together with condemnations, were greatly reduced in these birds.

In 1961-1962 work on Newcastle disease at Pulawy, Poland, under a PL 480 Grant, successfully demonstrated that yolk contained antibodies of immune dams decreased the virulence of Newcastle virus when it was passaged through them at least thirty times. The same results were obtained when the virulent virus was passed thirty times through eggs from susceptible dams if specific anti-serum had been introduced into the yolk sac prior to inoculation of the Newcastle virus. Parallel results were obtained by passing virulent Newcastle virus 20 to 30 times through immune 4 to 6-day old chickens, but not through immune 13 to 14-day old chickens.

F. Bluecomb in Turkeys.

In 1961-1962 investigations on this disease were begun under contract with the University of Minnesota. Suspected bluecomb infected turkeys from 28 commercial flocks have been subjected to study. Isolation of the causative agent by bacteriological, chicken embryo inoculation, and tissue culture technics has been successful in embryo inoculation in 12 instances. The agent has been passed by feeding and intraperitoneal injection of susceptible poults, and recovered from the intestinal tract 5 days after infection. The agent has been shown to be filterable, fairly resistant to antibiotics, and does not grow on non-living media.

G. Foot-and-Mouth and Other Exotic Diseases of Poultry.

In 1961, at the Plum Island Animal Disease Laboratory, the serological response of adult chickens to infective and non-infective preparations of two types of foot-and-mouth disease virus was studied. The peak of antibody following inoculation with infectious virus appeared approximately 28 days after inoculation. Low levels of complement-fixing antibody developed at 7 days after inoculation of non-infective virus. Chickens inoculated with infective tissue-culture virus and those inoculated with non-infective virus of the same type inactivated with acetyleneimine and beta-propiolactone, developed high levels of neutralizing antibody. Similarly chickens inoculated with formalin-inactivated A-119 virus produced in tissue cultures also developed high levels of antibody.

In 1962 no studies in this area were conducted at the Plum Island Animal Disease Laboratory

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PARASITES AND PARASITIC DISEASES OF POULTRY
Animal Disease and Parasite Research Division, ARS

Problem. Parasites and parasitic diseases probably cost the poultry industry at least \$40 million annually, by causing intestinal disturbances, emaciation, retarded growth, reduced egg production, and deaths. Parasites are ubiquitous, many times insidious, and often overlooked until birds are damaged irreparably. Early diagnosis is difficult, and reliable treatments for many devastating parasitoses are not available. Moreover, some management practices intended to avoid spread of parasites and to control them have been found ineffectual, as is shown by the increasing importance of certain parasites in broiler production. The problem is to develop, through a planned, balanced program of basic and applied research, methods for preventing, controlling or eradicating parasitic diseases, thus affording economical production of healthy poultry and sound products in supplies adequate to meet the needs of an expanding population.

USDA PROGRAM

The Department has a continuous long-term program involving parasitologists, biologists, and chemists, engaged in both basic studies and the application of known principles to the solution of the problem of parasites and parasitic diseases of poultry.

The Federal scientific effort devoted to research in this area totals 5.5 professional man-years. This effort is applied as follows:

Bionomics of Intestinal Protozoan Parasites 0.5 at the Beltsville Parasitological Laboratory, Beltsville, Maryland.

Immunology of Protozoan Parasitic Diseases 1.5 at the Beltsville Parasitological Laboratory, Beltsville, Maryland.

Control of Coccidiosis 2.0 at the Beltsville Parasitological Laboratory, Beltsville, Maryland.

Biology of Nematode Parasites 1.5 at the Beltsville Parasitological Laboratory, Beltsville, Maryland

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 6.2 professional man-years divided among subheadings as follows: Bionomics of Intestinal Protozoan Parasites 0.8; Control of Coccidiosis 3.4; Biology of Nematode Parasites 2.0. Investigations on Bionomics of Intestinal Protozoan Parasites are being conducted on the protozoan causing blackhead in turkeys, the pathogenesis of the disease caused by it in turkeys, and the continuous use of medicaments for the prevention of the disease. The Oregon Station is conducting an investigation on the Control of Coccidiosis to determine the characteristics peculiar

to the different species of coccidia of chickens and the effect of the different species on the host. Several States have studies to evaluate the efficacy of the various coccidiostats. A study on the Biology of Nematode Parasites to determine the nature of the older chicken's resistance to *Ascaridia* parasitism is under way at the Kansas Station. The Connecticut (Storrs) Station is studying Capillaria columbae parasitism in the chicken - its biology, effects on egg production, and methods of control. The effects of the anthelmintic piperazine citrate on egg yolk quality and egg production is also under study.

Industry and Other Organizations, chemical companies in particular, are engaged in the formulation of compounds and explorations for chemicals that may be used safely as parasiticides. Generally, these companies have their own facilities, including laboratories, poultry houses and other structures containing quarters for poultry. The work of these companies and the results, expenditures, and related matters are ordinarily confidential, since they involve eventually saleable products. Estimated annual expenditures are equivalent to approximately 25 professional man-years. These companies also make grants to State research institutions for investigations of the efficacy and safety of the products.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Bionomics of Intestinal Protozoan Parasites

In 1961 studies at the Beltsville Parasitological Laboratory showed that eggs of the poultry cecal worm, the vector of blackhead, and the blackhead protozoans contained therein were destroyed within one hour when they were immersed in 0.1 percent dilution of Beta-propiolactone (BPL) in water at a temperature of 85 to 90°F. The rate at which these organisms were destroyed by BPL was directly proportionate to the strength applied.

In controlled infections of birds with the nematode, *Heterakis*, and the protozoan, *Histomonas*, these nematodes acquired infections of the protozoans only after migrating from the intestinal epithelium into the lumen of the ceca, not during the 9 or so days spent in these tissues immediately following infection. In the female heterakids so infected, only about 1 of every 600 to 3,000 eggs that developed in the bodies of these females contained histomonads, it was calculated. Not all worms developed eggs containing histomonads, however. This calculation was based on findings from quantitative feeding tests with eggs from the *Heterakis* worms.

In tests this year acute blackhead was acquired by susceptible birds ranged on yards that became naturally contaminated with *Heterakis* and *Histomonas* 4 years previously, and which had been protected each summer by growths of vegetation. These tests are part of a long-range ecological study designed to lay a foundation for recommendations for the control of blackhead by rotation of ranges, in the absence of treatment of birds and other procedures which might aid in controlling this disease.

That the control of run-off from dashing rains may be an important management procedure in preventing the dissemination of blackhead from contaminated yards

to clean ones was shown by observations made during a period of several years. Eggs of the vector *Heterakis* survived and, after being washed onto clean plots, transmitted blackhead to susceptible birds ranged thereon. Plots with vegetation onto which the washings from contaminated plots flowed proved the most dangerous, because the vegetation impeded the flow of water, providing opportunity for the eggs to settle onto the soil where they became available to birds.

Observations this year indicated that oocysts of cecal coccidia of chickens and turkeys are more resistant to deleterious climatic factors than the oocysts of intestinal coccidia. In general, the survival of the former on experimental plots was approximately twice as long as the latter under similar conditions. On experimental plots, eggs of *Heterakis* containing *Histomonas* were found to have survived 78 and 73 weeks on shaded and unshaded soil plots, respectively. In the crop of chickens oocysts of an intestinal coccidium appeared to undergo no readily detectable changes. In the gizzard the oocyst shells ruptured, releasing the sporocysts (sac-like bodies containing the sporozoites which are invasive bodies). The latter did not emerge from the sporocysts until after these bodies had reached the duodenum, the site of infection. In the case of a cecal coccidium of turkeys, release of sporozoites was delayed until after the sporocysts were transported to the region of the yolk stalk or posterior to it.

A comparison was made of the in vitro excystation of oocysts of *E. acervulina*, *E. gallopavonis*, *E. meleagriditis*, and *E. tenella*. The oocysts of *E. acervulina* and *E. meleagriditis*, parasites of the duodenum, excysted much quicker than did those of *E. tenella* and *E. gallopavonis* which are parasites of the cecum. These in vitro studies parallel findings from in vivo studies in that sporozoites of *E. tenella* and *E. gallopavonis* were never found in the duodenum of test birds, whereas those of *E. acervulina* and *E. meleagriditis* were always recovered from that location at necropsy. These findings illustrate the perfect adaptation of these four coccidia to their hosts.

In 1962 studies at the Beltsville Parasitological Laboratory showed that in chickens one through four days of age the numbers of coccidial oocysts that hatched (excysted), the number and severity of lesions in the small intestine, the effect on the bird, and the number of oocysts produced per oocyst fed were least in the youngest birds and greatest in the oldest. It was also observed that a more severe coccidial infection resulted when oocysts were inoculated directly into the crop than when they were introduced into the small intestine. In chickens and turkeys it was shown that the oocysts begin hatching in the gizzard and is completed in the small intestine. The species that parasitize the small intestine survived the action of digestive enzymes in less time than those that parasitize the blind gut and surrounding areas. Two species each of chicken and turkey coccidia were used. In turkeys, blackhead begins usually from 4 to 18 days after the vector eggs are swallowed. The pathogenic form of the blackhead agent was proved to be more easily adapted to the vector, the cecal worm, than the nonpathogenic form.

The nonpathogenic variant of the blackhead organisms was determined to be a new species and given the name Histomonas wenrichi.

Studies on the in vitro excystation of sporozoites of poultry coccidia from mechanically released sporocysts showed that excystation is probably due to enhanced (by the action of bile salts) enzymatic activity of trypsin, chymotrypsin, and possibly lipase. The excystation rate induced by alpha- and beta-chymotrypsin was comparable to that obtained with an impure pancreatic preparation, trypsin 1-300, and much greater than that obtained with a highly purified preparation trypsin 2x. Significantly, carboxypeptidase A or carboxypeptidase B used alone, or in combination with a bile salt, failed to induce excystation. This selective enzymatic action suggests that the Stieda body (sporocystic plug), upon which the enzymes act, is composed, in part, of long-chained peptid linkages.

In connection with attempts to cultivate in vitro the poultry coccidium, Eimeria acervulina, in the duodenal cells of the host, a method was developed whereby chicks could be hatched and raised to 6 days of age with a much reduced intestinal flora. Cultures, prepared from duodenal tissue of such chicks, grown in a medium containing standard amounts of antibiotics (100 units of penicillin G and 300 micrograms of dihydrostreptomycin sulfate) were bacteria-free.

Gizzards of 1-day-old chicks which have less well developed musculature and smoother linings than gizzards of 2- and 3-day-old chicks, proved less susceptible to coccidial infections than older birds. A very low percentage of sporocysts were released from oocysts in gizzards of 1-day-old chicks and a low percentage of sporozoites escaped from liberated sporocysts in the small intestine. Two- and 3-day-old chicks were progressively more effective in excysting oocysts. A motion picture on the excystation (hatching) and locomotion of sporozoites of poultry coccidia was prepared in collaboration with scientists of the UCLA.

B. Immunology of Protozoan Parasites.

In 1961 at the Beltsville Parasitological Laboratory, in work to control blackhead by immunization against its vector, the poultry cecal worm, the incidence of blackhead was 37 percent lower in a group of poults so immunized and run on a plot infectious for cecal worms and blackhead, and 42 percent fewer birds died from blackhead than was the case in a comparable, non-immunized control group. The number of cecal worms recovered from the immunized birds at necropsy was 46 percent less than from the controls. "Immunization" against these worms was accomplished by the administration to each bird of 100 embryonated eggs known to be free of blackhead parasites.

Experimental work with the turkey coccidium Eimeria gallopavonis, revealed that this parasite is capable of causing sickness, loss of weight, and death of affected birds as old as 7 weeks. That portion of the intestinal tract surrounding the cecal juncture was generally affected most severely. Birds that survived an initial infection were found to possess a high degree of

resistance to subsequent massive infections of this parasite. After the oocysts were swallowed by susceptible birds approximately 144 to 150 hours were required for the parasites to excyst, complete their cycle of development, and for new oocysts to appear in the droppings.

In work to develop a procedure that could be used in immunizing chickens against several species of coccidia at one time, a single dose of coccidial oocysts comprised of three or four of the more pathogenic species, did not confer a satisfactory degree of resistance to any one or to all of the species involved. This is shown by the fact that all these birds "challenged" by means of an inoculum containing three species (E. tenella, E. necatrix, and E. acervulina) or four species (E. tenella, E. necatrix, E. maxima, and E. acervulina) exhibited pronounced clinical symptoms of coccidiosis severe enough to result in death of a sizeable number of the birds involved.

In 1962 at the Beltsville Parasitological Laboratory, studies showed that a single infection of turkeys with the coccidium Eimeria gallopavonis can be harmful to birds 3 to 12 weeks old. However, turkeys that survived an initial infection of the coccidium were immune to a second (challenge) infection of this parasite, administered 29 days after the first. None of the immunized birds became sick, none died, and the digestive tract was undamaged. Of the control, nonimmunized birds, 20 to 100 percent died, with severe infections.

C. Control of Coccidiosis.

In 1961 at the Beltsville Parasitological Laboratory, Beltsville, Maryland, in studies of the reaction of the cecal coccidium Eimeria tenella to drugs recommended for treatment, strains of this parasite having varying degrees of resistance to nicarbazin, Unistat, Trithiadol, nitrofurazone, and arsenosobenzene were produced experimentally. An experimentally developed strain resistant to nitrofurazone was tested for cross-resistance to Unistat, nicarbazin, arsenosobenzene, glycarbylamide, Trithiadol and Zoalene, but no evidence of cross-resistance was observed. Studies to develop a strain of E. tenella resistant to amprolium were unsuccessful.

Preliminary work with terephthalic acid as a "potentiator" of aureomycin administered in feed for the control of cecal coccidiosis of chickens yielded promising results. A combination of terephthalic acid (0.5 percent) and aureomycin (0.0055 percent) in feed afforded 3-week-old chickens complete protection against mortality from experimentally induced coccidiosis and enabled the infected birds to grow at a rate comparable to that of uninfected, unmedicated controls under experimental conditions. Neither compound by itself administered in feed afforded demonstrable protection to birds under experimental conditions. The medicated mash was given 24 hours before the birds were infected, and continued for 14 days.

In 1962 at the Beltsville Parasitological Laboratory, strains of Eimeria tenella, serially passed 21 times through groups of chickens receiving nicarbazine, Unistat, Trithiadol, or arsenosobenzene in the feed, developed varying degrees of tolerance to the respective coccidiostats. The decreased sensitivity

was reflected by increased severity of cecal lesions, increased oocyst production, and general unthriftiness of the experimental birds.

Chlortetracycline in the feed at a level of 0.0055 percent (50 grams per ton), when potentiated by 0.5 percent terephthalic acid, gave complete control of cecal coccidiosis in some birds but not in others.

An analysis of the sporulation rates of E. tenella oocysts in droppings of chickens fed various coccidiostats indicated that the chemicals fed did not adversely affect sporulation. When the coccidiostats were mixed with oocyst-containing droppings for laboratory culturing, however, sporulation was inhibited in cultures containing nicarbazin, Zoalene, amprolium, and Unistat.

A strain of E. tenella that was serially passed through chickens fed sub-optimal levels of amprolium developed a tolerance for this low level of the chemical. However, after 9 such passages the strain was still fully susceptible to the usual field level of amprolium.

D. Biology of Nematode Parasites.

In 1961 at the Beltsville Parasitological Laboratory, the discovery of many immature larvae of Ascaridia columbae in the livers of pigeons following heavy experimental infections with this nematode, as reported last year, gave rise to the belief that this parasite may have a migratory phase in its life cycle similar to that of ascarids of non-avian hosts. Tests conducted this year demonstrated that A. columbae does not have a migratory phase outside the digestive tract but completes its development within the small intestine. Larvae encountered in the liver of birds to which large numbers of embryonated eggs of A. columbae were administered were found to become encapsulated and did not leave that organ to complete their development. The additional finding of immature stages of the parasite in the mucosa of the jejunum and ileum indicated that the true migratory phase was limited to the intestinal lining. It was determined that 30 to 35 days were required for A. columbae to complete its life cycle in the pigeon.

A severe outbreak of gapeworm infection causing death losses in pheasants was studied. Feeding turkey poults the earthworm Helodrilus foetida and H. caliginosus from the soil of the pen in which the pheasants were confined established the fact that these worms were an important source of infection. Eight of 12 turkey poults failed to survive the feeding of 10 of the gapeworm-infected earthworms and at necropsy harbored about 50 pairs of gapeworms per bird. The average weight of the 4 surviving infected birds was 171.9 grams less than that of the uninfected controls at the termination of the experiment at the end of 25 days. In cooperation with the Nematology Section of the Plant Industry Station, an experiment was carried out to determine the effectiveness of soil fumigants for the control of gapeworm infection by destroying infected earthworms in the soil. Selected plots (10 feet square), known to contain infected earthworms, were treated with methyl bromide or with DD, a mixture of Dichloropropene and Dichloropropane. One pound of methyl bromide per 100 square feet of soil surface killed about 98 percent of the earthworms in the top 8 inches of soil when it was applied under a vapor-proof cover. When

DD was applied at the rate of 30 and 50 gallons per acre, respectively, by means of an applicator, it was relatively ineffective.

Cockroaches are known to serve as intermediate hosts of certain species of helminth parasites of birds. An attempt was made to infect three species of roaches, Periplaneta americana, Supella supellectilum, and Blatella germanica, with eggs of the gapeworm, Syngamus trachea, mixed in feed. Turkey poults became infected with this parasite when fed P. americana and S. supellectilum 2 days after exposure. Turkeys fed similarly exposed B. germanica did not become infected.

In order to expedite experimental work with poultry helminths, methods of culturing embryonated eggs and of hatching them in vitro were investigated. Dilute aqueous solutions of formalin (0.2 to 6.0 percent) were used in attempts to increase the infective larvae developing in the unhatched eggs of Capillaria obsignata. Only a small percentage of these eggs were infective to chickens when cultured in this way. The largest percentage hatched and continued their development when cultured in 0.5 percent formalin.

In a study of the hatching mechanism of the eggs of Heterakis gallinae, a number of female worms containing embryonated eggs were fed in No. 2 capsules to five 4-week-old chicks. The birds were killed 1, 2, 2-1/2, 3, and 4 hours after ingesting the capsules. At the end of 1 hour, unbroken capsules containing intact worms were recovered from the crop; in 2 to 2-1/2 hours unhatched eggs and fragments of worms were recovered from the gizzard; in 3 hours larvae were recovered from the ileum, but no unhatched eggs or larvae were seen elsewhere in the intestine; and by the fourth hour, larvae were found near to the entrance to the ceca. These observations indicated that the gizzard functions to break up the capsules and the worms thus freeing the eggs for action by the digestive juices of the intestine.

Young chicks placed on litter contaminated with the eggs of the large intestinal roundworm of chickens, Ascaridia galli, and the threadworm of chickens, turkeys, and pigeons, Capillaria obsignata, and exposed to such litter for two periods of 5 and 4 days each, with an intervening period of 10 days, weighed on an average of 92.1 grams less than similar control birds kept on clean litter. Although the infected birds did not become heavily infected, (1 to 11 A. galli and 1 to 4 C. obsignata) the acquisition of parasites and the exposure to used litter points up the fact that chickens require sanitary conditions for their best development.

In 1962, in studies at the Beltsville Parasitological Laboratory, the life cycle of Ascaridia columbae, the large intestinal roundworm of the pigeon, was completed experimentally for the first time under controlled conditions. The embryos within the eggs developed to the infective stage in approximately two weeks at room temperature. In the pigeon, the larvae attained the third stage of development between the third and sixth days, the fourth stage between the 11th and 14th days, the fifth stage at about the 17th day, and eggs appeared in the feces 37 to 42 days after experimental infection. This work also demonstrated that the parasitic phase of the life cycle was completed entirely within

the alimentary tract. Although larvae were observed in the liver, portal vein, bile duct and lungs of experimentally infected pigeons, no evidence was obtained to support the hypothesis advanced earlier in the investigation, that a migratory phase outside the digestive tract might be necessary for the completion of the life cycle. Histological examination of the lesions produced in the liver by migrating larvae of Ascaridia columbae disclosed that their cellular composition changed with the age of the infection.

Methyl bromide was demonstrated to be an effective soil fumigant for the destruction of the earthworm intermediate hosts of the poultry gapeworm, Syngamus trachea, for the control of this parasite in pheasants.

Thiabendazole, a new drug having the chemical formula 2-(4-Thiazolyl)-benzimidazole, when mixed in mash in the proportion of 0.3 percent of a 10 percent premix by weight and fed continuously for 12 days was not effective in removing the large roundworm, Ascaridia columbae, and the intestinal redworm, Ornithostrongylus quadridadiatus, from pigeons. However, it sharply reduced worm egg production of both species, but had little or no effect on the production of oocysts by coccidia.

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POULTRY INSECTS
Entomology Research Division, ARS

Problem. Numerous species of insects, mites, and ticks are common pests of poultry throughout the country and if not controlled can make poultry raising unprofitable. They cause poultry to look unsightly, reduce weight gains and egg production, and mar the skin, which results in downgrading of quality and lower market prices. Pests such as black flies and mosquitoes transmit leucocytozoon and fowl pox diseases which exact a heavy toll in death and unthrifty poultry each year. House flies spread parasites and enteric diseases which may decimate flocks. Safer, more effective, nonresidue-forming insecticides are needed to combat these poultry pests and vectors of diseases of poultry. Better materials are needed for direct application to poultry or in poultry houses to control lice, mites, and ticks and for use as larvicides or fly baits to control flies. Materials are especially needed which, when given in feed or water, would act systemically to control external pests and render droppings toxic to fly larvae. Exploratory studies are needed to investigate possibilities of developing attractants, chemosterilants, antimetabolites, or other new methods of combatting poultry pests. Biological and sanitation methods of control offer excellent possibilities for control and need to be emphasized. There is a special need to investigate the roles of insects, ticks, and mites in the transmission of poultry diseases.

USDA PROGRAM

A continuing study is underway involving basic and applied research on insects, mites, and ticks that affect the health and productivity of poultry. Studies are designed to determine breeding habits and reproductive capacities of various poultry pests and to gain further knowledge on the nature of resistance of these pests to certain insecticides. Work at present is devoted mostly to lice and the northern fowl mite, and to the house fly, which breeds abundantly in poultry droppings. A newly expanded program aims to find new ways to control pests of poultry with special emphasis on chemosterilants, antimetabolites, attractants, and noninsecticidal materials and methods. Current studies in this field are largely limited to house flies.

Some attention is being given to the development and testing of attractants; and physical and mechanical methods of controlling house flies are being investigated in cooperation with the Agricultural Engineering and Animal Husbandry Research Divisions.

Research is concerned with the development of more effective insecticides for the control of poultry pests. New chemicals are screened for contact and residual toxicity to lice and mites attacking poultry and to house

flies, and promising ones are tested for effectiveness under practical field conditions. New methods of utilizing insecticides more efficiently and safely are being investigated, with special attention to finding materials that, when given orally in water or feed, will act systemically to kill lice and mites on the poultry, and render the droppings toxic to fly larvae. Efforts are also being given to methods of sanitation and management to control fly breeding in accumulations of manure in poultry houses. Studies are conducted to determine the occurrences of residues in tissues of poultry treated with insecticides. Work is done in cooperation with poultry raisers at Orlando, Fla., Stoneville, Miss., Corvallis, Oreg., and Kerrville, Tex.

The Federal scientific effort devoted to research in this area totals 2.2 professional man-years. Of this number, 0.4 is devoted to basic biology, physiology, and nutrition; 0.9 to insecticidal and sanitation control; 0.2 to insecticide residue determinations; 0.6 to insect sterility, attractants and other new approaches to control; and 0.1 to program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 3.3 professional man-years divided among subheadings as follows: Basic biology, physiology, and nutrition 0.5; insecticidal and sanitation control 1.8; insecticide residues 0.8; insect sterility, attractants, and other new approaches to control 0.1; and insect vectors of disease 0.1.

Industry, especially chemical companies and distributor companies, are engaged in research on formulation and evaluation of insecticides for control of poultry pests. Industry also cooperates with Federal and State workers in developing information on residues resulting from the use of promising insecticides in connection with label registration. The cooperation of poultry raisers in providing large numbers of poultry is of inestimable value in the field evaluation of insect control by Federal and State workers and represents a significant contribution by poultrymen to the total research efforts. Estimated annual expenditures by industry are equivalent to approximately 5 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic Biology and Physiology

1. House Fly. Studies in Oregon showed that DDT-resistance in house flies was attributable to the ability of the flies to dehydrochlorinate the insecticide. The mechanism of resistance in house flies to the carbamates was due to aliesterase activity - the same as for the organophosphates.

In Oregon certain synergists (simple tris-substituted derivatives of phosphoric acid) completely overcame high levels of malathion resistance in house flies. The most effective materials increased the toxicity of malathion from 36- to 40-fold against the resistant flies. The relative ability of several of the synergists to synergize malathion against the resistant flies (little or no effect with normal flies) was directly related to the inhibitory effect of the synergists on ali-esterase activity. The synergists may actually inhibit the mutant ali-esterase present in all organophosphate-resistant fly strains. House flies treated with the synergist tributyl phosphorotrithioate and then treated with either parathion or paraoxon accumulated greater quantities of paraoxon than did flies treated with the toxicants only.

In Oregon selection of a house fly colony with Isolan produced a strain with 3-fold resistance in 14 generations. At the same time, levels of esterase activity to methyl butyrate declined to 40% of the original level in flies of the selected strain. This same phenomenon occurs when house flies are selected with organophosphates, indicating that the same mechanism is responsible for resistance to both classes of insecticides.

Studies in Oregon showed that house flies are capable of dispersing a distance of at least 5 miles in 24-48 hours.

In Florida cytological studies showed that the ovaries in normal 3-day-old flies were 6-8 times as large as those in females fed for 3 days on 1.0% apholate. After feeding ceased some growth occurred but ovaries never attained normal size. Females mated to males fed on 0.4-1.0% apholate oviposited but the eggs showed little or no embryonic development, whereas females mated with males fed 0.1-0.3% laid some viable eggs and some without embryonic development. Similar results were obtained in tests with normal and insecticide-resistant strains of flies.

In further studies on the cytological effects 1% apholate given in adult food over a period of 24 hours inhibited but did not eliminate ovarian development in females. The greatest effect was noted at 72 hours after eclosion of the nurse cells in the first and second egg chambers. The chromatin was irregular and nuclei had bizarre shapes. Oocytes matured in the first cell but not in the others. The germarium was also affected as the third egg chamber was not visible until 168-192 hours after eclosion compared to 96 hours in normal flies.

2. Mosquitoes. Studies were initiated at Fresno, Calif., in July, 1961 on the biology of mosquitoes in relation to agriculture, especially with regard to irrigation and land management practices, in cooperation with the Soil and Water Conservation Research Division and The Bureau

of Vector Control of the California State Department of Health. Early studies showed that dairy drains are sites of heavy breeding of Culex quinquefasciatus through November and into early December. The breeding in such locations contributes heavily to overwintering adult population of this species. No autogeny (ability to lay eggs without a prior blood meal) was observed in this vicinity with Aedes vexans, Culex apicalis, C. peus, and C. thriambus.

In Oregon, studies on flight movements of tarsalis indicated that they move from their resting stations about sunset and return about sunrise. The instinct of tarsalis to oviposit in low sites is stronger than the instinct for oviposition in favorable waters. Female tarsalis mate only once, whereas males mate several times.

In other studies in Oregon on the physiology of resistance, malathion-resistant larvae of Culex tarsalis were more efficient in regulating salt (chloride) uptake than susceptible larvae during exposure to malathion. Resistant and susceptible larvae take up similar amounts of chloride when exposed to 1% sodium chloride alone. Exposure to 1% sodium chloride resulted in an increase in oxygen consumption in susceptible and malathion-resistant larvae, but chloride had no measurable effect on cholinesterase inhibition or accumulation of malaoxon, the principal breakdown product of malathion in mosquitoes. Studies of the insect enzyme systems, cholinesterases and aliesterases, led to the development of synergists for organophosphorus insecticides. Several tris-substituted derivatives of phosphoric acid overcame the resistance of tarsalis larvae to malathion, increasing its toxicity 100-fold to a resistant strain. Only about a 2-fold increase was indicated against normal strains. The ability of the synergists to overcome resistance appears to be related to an increase in the titer of a carboxyesterase enzyme. In general, the accumulation of malaoxon was proportionate to the effectiveness of the synergist. Malathion-resistant tarsalis detoxify DDT 2- to 3-times as fast as normal strains, largely through the formation of carboxylic derivatives. The DDT detoxifying enzyme, DDT-dehydrochlorinase, in flies does not occur in tarsalis.

Studies in Florida showed that metepa was picked up rapidly by tarsal contact from glass surfaces by both mosquitoes and house flies. House flies and Aedes quadrimaculatus absorbed approximately the same amount (7 µg./insect) during a 4-hour exposure on surfaces treated at 10 mg./sq. foot. The quadrimaculatus males were so damaged that they could not inseminate the females but house fly males were normal in this respect and 99% of the eggs produced from matings with virgin untreated females were nonviable. A. aegypti showed an average uptake of 2.5 µg./insect, which sterilized but apparently did not impair male activity. Feeding for 3 days on treated food (1% in 20% honey solution) with

mosquitoes, and 0.4% in house fly food sterilized quadrимaculatus males and caused a high degree of sterility in house fly and aegypti males. At the end of the 3-day feeding period the amount of tagged material, expressed at ug.-equivalents of P³² metepa was 3.0, 3.7, and 1.7 in males of quadrимaculatus, house flies, and aegypti, respectively. Exposure of larvae from the third instar through pupation in water treated at 10 p.p.m. failed to sterilize quadrимaculatus or aegypti significantly and the uptake of metepa was low in comparison to the other types of treatments.

Studies in Oregon showed that P³² metepa was rapidly absorbed and metabolized by house flies, mosquitoes (Culex tarsalis) and mice. Almost complete degradation occurred in 24 hours with phosphoric acid being the major metabolic product.

In the field in central Florida the number of Anopheles quadrимaculatus adults generally decreased in January and February and increased little in March, April, and May (water level low). The counts increased in the last quarter of the year, even though rainfall was deficient and water levels remained low. The females in the breeding area generally outnumbered the males, often better than 2:1. Throughout the year some of the eggs laid by wild females failed to hatch, indicating some sterility in nature. The sterility in nature appeared highest in September and October. Two wild females that had laid eggs had no sperm. A higher percentage of the females collected at the breeding site had laid two or more batches of eggs than those found away from the water. Studies with laboratory colony males and females indicated males were capable of fertilizing about 1.5 females each in a 3-day period.

B. Insecticidal and Sanitation Control

1. House Fly. In Florida, approximately 175 new compounds were screened for residual effectiveness against house flies. Twenty-four materials were 98-100% effective for at least 24 weeks as compared with 12-16 weeks for malathion (standard). These were Thiodan, General Chemical GC-3583, Shell SD-4402, Upjohn TUC U-12927 (with synergist); Bayer compounds 29952, 30237, 30468 and 29492; Hooker HRS-1422, Geigy G-27365, Stauffer N-2404, heptachlor epoxide; and 12 confidential compounds. Bayer 29952, Bayer 30237 and seven of the confidential compounds were still 100% effective after 44-48 weeks and are considered unusually promising for controlling flies. A number of promising new compounds were evaluated as space sprays against susceptible and resistant strains of house flies. Several of the compounds were superior to malathion (standard) against susceptible flies but only one, Bayer 30911, was superior against resistant strains.

In Florida, over 50 selected compounds were evaluated as bait toxicants against resistant and normal strains of house flies. Eight of the compounds were equal or superior to Dipterex (standard) against both strains of flies, namely: Bayer 30237, Bayer 30554, General Chemical 6506, Stauffer N-2230, Stauffer N-2404, dimethoate, and two confidential compounds. All of the compounds tested were more effective against normal than against resistant flies.

In Florida several materials which increased the effectiveness of malathion in laboratory tests were evaluated as residual treatments in barns against material populations of flies. Combinations of several synergists and malathion alone were equally ineffective in these tests.

2. Mosquitoes. Research was continued by the Orlando, Fla., and Corvallis, Oreg., stations to develop more effective insecticides and other materials for controlling mosquitoes. In Florida, of over 500 new compounds screened for toxicity to Anopheles quadrimaculatus larvae, five were outstanding in their effectiveness. Of seven selected compounds screened against Culex tarsalis in Oregon, three were outstanding.

Studies were continued in Florida to find more effective residual insecticides for the control of adult mosquitoes. Of 157 selected compounds screened against female adults of Anopheles quadrimaculatus, 17 were very promising, causing 90 to 100% kill of exposed quadrimaculatus for 24 weeks. Four of the compounds, Bayer 39007, Hercules 7522C, Bayer 34098, and Bayer 4183 retained their effectiveness on sprayed surfaces for 1 year. In tests with treatments that had aged for 2 years, Sevin and Hercules AC-5727 plus piperonyl butoxide caused 85% kills of quadrimaculatus within 24 hours after a 1-hour exposure to 100 mg./square foot, whereas malathion and unsynergized AC-5727 were ineffective.

In Florida, tests in the laboratory and field were continued to develop more effective materials for mosquito control. Of 151 selected compounds tested as space sprays against colonized Aedes taeniorhynchus, four were better than the malathion standard: Kenya Oleo Resin, Bayer 34042, Bayer 30749 and Hercules 7522C. In aerial spray tests against natural populations of salt-marsh mosquito adults, 0.05 pound per acre of Dibrom or DDVP was about as effective as 0.1 pound of malathion per acre. These sprays reduced mosquito abundance more than 90% in 6 hours.

In Oregon, screening tests were conducted with a number of new insecticides against larvae and adults of Culex tarsalis. Three of the materials gave 100% kills of larvae at a concentration of only 0.025 p.p.m. In spray tests seven materials were 2 to 9 times more toxic to adult mosquitoes than malathion (standard) and two of these compared favorably with parathion.

3. Lice and Mites. In comparative tests with various insecticides as sprays in Mississippi, Zectran at 0.025, Hooker HRS-1422 at 0.05, and Shell SD 4294 (Ciodrin) at 0.1% gave complete control of the northern fowl mite and lice. When tested by dipping only the tails of chickens, Sevin at 0.5% was the most effective material against mites and lice. However, malathion at 0.5 and GC-4072 at 0.25% eradicated lice and greatly reduced mite infestations. In field flock tests, tail dipping with 0.25 and 0.5% Sevin eradicated mite infestations. When applied as litter treatments, 1 pound of 5% Zectran or Sevin dusts per 80 square feet failed to give consistently satisfactory control of mites but were effective against lice. However, 50% dusts of Sevin applied in pits and nest boxes eliminated mite infestations. Four weekly sprayings of coops and roosts eliminated the northern fowl mite in one location, but not in seven others, although high reductions in populations occurred. Feeding Ruelene to chickens at rates of 10-30 mg./kg. for 3 days had no effect on louse or mite populations.

Eleven chemicals were tested in Texas for control of poultry lice on chickens. Nine of the compounds and the malathion standard controlled all species of lice through a 27-day period at levels as low as 0.1%. Dibrom was effective at 0.25%. The materials were applied as sprays directly to the individual birds.

C. Insect Sterility, Attractants, and Other New Approaches to Control

1. House Fly. Studies in Oregon indicated that irradiation of resistant flies with sub-sterilizing doses of 1000 r did not alter their susceptibility to insecticides or esterase activity. Treated females mated with untreated males oviposited normally but only 45% of the eggs hatched. Additional studies were conducted with normal and parathion-resistant flies that had been irradiated as pupae with 600 r for seven generations. Only about 25% of the eggs hatched from matings of irradiated males and females of either colony. No changes in insecticide susceptibility or esterase activity were apparent.

The following studies were conducted in Florida in connection with control of the house fly in dairy barns, poultry houses, households and industrial establishments. Irradiation caused greater damage to early (2-4 days old) house fly pupae than to middle-age pupae. Virtually no damage was apparent in old pupae and longevity of adults was greater than that of younger pupae. Irradiation of pupae 0-36 hours before adult emergence did not produce complete sterility and some recovery was indicated since second matings resulted in a slight increase in progeny. No recovery occurred in pupae irradiated 72-96 hours before adult emergence.

Extensive studies were conducted to find materials that would induce sterility or otherwise affect the growth and development of the house fly. Of about 1300 compounds tested in the adult food, twenty-one

caused sterility in flies. Only one of about 800 materials tested in the larval media caused sterility but nearly one-third were toxic to the larvae. In secondary tests with 59 compounds that had shown promise in screening tests, twenty-seven caused sterility (no oviposition or hatch) at concentrations of 1% or lower. Additional tests were run with 50 promising materials applied as larval dips, topically to adults, and in the adult food. None caused sterility as larval dips but in adult food, six induced complete or nearly complete sterility. Two other materials were effective only as topical applications.

Special tests were run with 24 promising chemosterilants to ascertain the effects on each sex. Only one material, an aziridiny1 compound, caused sterility in both sexes. Methiotepa, 5-fluoroacetic acid, metepa, and a confidential material caused complete sterility in males but not always in females. Three materials - 5-fluoroacetic acid, an aziridiny1 compound, and 5-fluorouracil were effective when fed to both sexes.

Extensive studies were conducted to learn more about the action of several effective chemosterilants on house fly sexual development, mating and reproduction. In one series of tests, males sterilized by feeding 3 days on apholate proved fully competitive with normal males when placed with normal females. When only treated males were placed with normal females all eggs were sterile and 12.5% were sterile when only normal males were present. When normal females, normal males, and treated males were combined at ratios of 1:1:1 and 1:1:2, 65 and 80% of the eggs were sterile and higher ratios of 1:1:3, 1:1:5, and 1:1:10 resulted in 99.9-100% sterility. Additional tests at these ratios confirmed that actual sterility was higher than the expected. Males given food containing 0.4-1.0% apholate for 3 days were sterilized for life but lower concentrations of 0.1-0.3% were not 100% effective. Exposures of males on residues of 500-1000 mg./kg. of tepa on plywood panels caused only partial sterility (12-72%) but when applied at 250-500 mg./sq. ft. with sugar, tepa and apholate produced 91-100 and 99-100% sterility, respectively. When applied in glass jars, residues of 250 mg./sq. ft. of tepa or metepa completely sterilized flies in 2-4-hour exposures for 30 days but not for 60. Deposits of 100 and 50 mg./sq. ft. caused complete sterility for 14-30 and 14 days, respectively, but deposits of 10-25 mg. were mostly ineffective. Baits containing 0.5% of tepa and metepa effectively sterilized flies after aging 30-37 days on most types of surfaces. Some loss in effectiveness in tepa was apparent on metal and masonite and in metepa on wood, but none was apparent on painted wood, asphalt, metal or wax paper.

In Florida weekly applications of corn meal bait containing 0.5% tepa on an isolated refuse dump reduced adult house fly populations from 47 to 0 in 4 weeks and counts remained at 0 as long as the bait was distributed. The viability of eggs of female flies declined

from 100 to 10% in 4 weeks and to 1% in 5 weeks. After baiting ceased, populations increased slowly but the percent viability of eggs was normal after 2 weeks. Additional small-scale field tests with corn meal-chemosterilant baits against flies were conducted on a small garbage dump and in a poultry house. Weekly applications of apholate baits on the dump and of metepa baits in the poultry houses caused some sterility and reduction of fly populations. Applications 5 days a week resulted in a high degree of control and high sterility in flies in both areas.

2. Mosquitoes. In Florida, extensive studies were conducted with the chemosterilants, apholate, tepa, and metepa. In laboratory tests with Anopheles quadrimaculatus and Aedes aegypti sterility could be induced into both males and females by feeding the chemicals in adult food (honey - water), by allowing adults to walk on deposits on glass or masonite surfaces (tarsal contact) or by exposing larvae to the materials in water solutions. However, two of the three compounds were not effective in one of the three methods of administration: apholate did not sterilize by tarsal contact and metepa did not sterilize when larvae were exposed to it. A residual deposit of tepa sterilized males from the laboratory colony that were 0 to 5 days old, females from the laboratory colony that were 0 to 24 hours old, and wild-collected females that had previously mated, had a blood meal, and developed one to five batches of eggs. In general, depending on the dosage, treated females either had stunted ovaries and laid no eggs or laid eggs which did not hatch. When treated males were mated to untreated females, the females received motile sperm and laid normal numbers of eggs which did not hatch. In some cases with either treated males or females, an occasional egg hatched. Most of the eggs laid by females mated to treated males showed no or disorganized development; some eggs embryonated normally, but did not hatch. Artificial resting stations for A. quadrimaculatus were established in a breeding area in the field and treated with tepa. These deposits were effective in sterilizing wild females that rested in them (males could not be studied, but presumably were sterilized) completely; however, the deposits remained effective for only a few days. No sterility was found in females collected outside the treated boxes, indicating that this method did not affect a significant part of the total population. Release of gamma- or chemosterilized A. quadrimaculatus males into natural populations have been ineffective to date in influencing wild populations.

In Oregon studies were conducted with a number of chemosterilants. Unfed virgin female Culex tarsalis from 1 to 6 days old did not produce eggs after being sprayed with 5% tepa. Adults feeding on sugar containing 0.1% apholate were completely sterilized. Females produced from larvae exposed in 1 to 3 p.p.m. of tepa laid normal numbers of viable egg masses but at 10 p.p.m. very few eggs were produced and

viability was less than 1%. Adults emerging from water containing 10 p.p.m. of apholate did not lay viable eggs. Female mosquitoes were sterilized by feeding on mice which had received oral doses of 10 mg./kg. of metepa or 50 mg./kg. of apholate but lower doses were not effective. Maximum effects were apparent only in adults feeding from 15-60 minutes after the mice had been treated. Studies with a radioactive chemo-sterilant showed that the material was rapidly absorbed and metabolized by mosquitoes and mice. Almost complete degradation occurred in 24 hours.

In Oregon studies were conducted to determine the effects of irradiation on various stages of C. tarsalis. Dosages required to kill 100% of the various stages were as follows: eggs, 800-1000 r; larvae, 150,000-180,000 r; pupae 80,000 r; and adults 100,000 r. Sterilizing doses were 5000 r for females and at least 10,000 r for males. Doses up to 15,000 r had no effect on adult longevity but 25,000 r was definitely harmful.

In Oregon approximately 200 chemicals and other materials were tested to determine whether they would repel or attract oviposition by Culex pipiens quinquefasciatus or C. tarsalis. Several materials attracted more oviposition than distilled water but hay infusion was the most effective. A number of materials apparently were repellent and prevented oviposition by females. The most repellent materials were emulsifiers, the best of which were effective at only 2.0 p.p.m. Over 100 chemicals and other materials, including sex extracts, were evaluated as attractants for Culex tarsalis and C. pipiens quinquefasciatus. None of the materials was as attractive as the carbon dioxide standard.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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EQUIPMENT AND BUILDINGS USED IN POULTRY PRODUCTION
Agricultural Engineering Research Division, ARS

Problem. Economic conditions are causing farmers to step up their efforts to reduce production costs and improve quality by reducing labor and modifying environment in poultry production. Labor is an important element in production costs. How to make better use of equipment and to adapt existing buildings and other facilities for more efficient production as flocks are increased in size and farms consolidated are major considerations. Cost of replacement or major improvement of existing buildings that are not suited to modern production methods are serious obstacles. Principles, examples, and techniques for planning more efficient operations are needed both by farmers doing their own engineering and by those on whom farmers depend for advice.

Research has shown that temperature, light, space, and other environmental factors affect the growth, health, fertility, production, and feed consumption of farm animals and poultry. Thus, savings in feed, reduced losses from disease and exposure, and decreased costs of production may justify many environmental improvements. The normal season during which turkey breeder hens produce fertile eggs is quite short, with resultant high egg cost. Engineering the quality and quantity of light to increase the season for hatchable eggs offers an opportunity for more efficient production.

USDA PROGRAM

This is a continuing program involving engineers and architects conducting basic laboratory investigations, application of laboratory results to a production basis, and development of typical plans for livestock structures. The work is in cooperation with the AH, ADP and ENT Divisions of ARS, USDA, and State Agricultural Experiment Stations, and contributes to Cooperative Regional Projects NC-23, "Farm Structures to Meet Environmental Requirements of Dairy Cattle, Swine, and Poultry," S-49, "Genetic Methods of Improving Dairy Cattle for the South," and NE-8, "Essentials of Poultry Housing for the Northeast." Development work on building plans is cooperative with all the State Agricultural Experiment Stations and Extension Services.

Poultry house environmental design criteria are investigated in controlled-temperature laboratory studies at Beltsville, Maryland, in cooperation with AH, ARS. Field studies on relation of housing structures to poultry disease are conducted in Mississippi in cooperation with the State Station and AH, ARS. Environmental influences on health and housing are to be investigated in new laboratories at Athens, Georgia, and State College, Mississippi, in cooperation with AH and ADP, ARS, and the respective State Agricultural Experiment Stations. At St. Paul, Minnesota, a study of the role of environment in the pre-

vention and control of chronic respiratory disease in turkeys is underway in cooperation with the Minnesota Station. Typical plans for poultry structures are developed at Beltsville. This work involves 3.1 Federal professional man-years. Equipment and control for automatic feeding of livestock and poultry is under development in Washington and Illinois State Experiment Stations, involving about 0.5 Federal professional man-years.

Research on equipment for basic and applied studies involving light and thermal environment for poultry is underway at Beltsville in cooperation with the Poultry Branch, AH, ARS. At Athens, Georgia, basic studies are underway involving diurnal variations of temperature, humidity, and air velocity effects on growing broilers in cooperation with the Poultry and Agricultural Engineering Departments, University of Georgia, involving 2.2 Federal professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

The Experiment Stations in 1961 reported the following professional man-years of effort: poultry buildings, 9.7; poultry equipment, 0.7; and an estimated 4.3 professional man-years of research on equipment for environmental control for dairy cattle, swine and poultry; and for engineering phases of application of light to animals and poultry, 1.6 professional man-years.

Poultry building studies in progress at many of the State stations are attempting to establish basic data on environmental adaptation criteria for poultry housing and functional design requirements. These investigations are concerned with such problems as measurements of the effects of light, air movement, temperature and humidity on economy of production of both broilers and layers. Data on these and other factors are guiding the systematic design and evaluation of new and improved poultry structures and equipment. These coordinated studies are a part of Cooperative Regional Projects NC-23 and NE-8.

Investigations to analyze and to develop and test equipment for systems to mechanically feed and service beef and dairy cattle, swine, and poultry are in progress. These studies involve the design and installation of automatic feeding systems for blending mixed rations and roughages according to various levels of production and the removal of waste materials. The primary objective of these studies is to arrive at suitable methods and equipment to reduce the labor now required and thus reduce unit cost of production. Part of this research is cooperative with the USDA.

In industry several manufacturers of metal and other types of prefabricated buildings have been actively testing the performance of their buildings for housing dairy and beef cattle, swine and poultry. Estimated annual expenditures in 1961 were equivalent to approximately 20 professional man-years. Manufacturers of lumber, cement and other materials have been developing new materials, investigating their applications and determining construction techniques for their use. However, most of this research has been directed to supplying the larger markets provided in industrial structures and nonfarm dwellings. Estimated annual expenditures directly benefiting farms in 1961 were equivalent to approximately 30 professional man-years.

Most manufacturers of "on-the-farm" equipment for livestock and poultry are engaged in testing the performance of their product design and developing improved products. Some are also investigating farm application of products designed for other uses and a lesser number are developing new equipment or methods to meet specific problems in the livestock and poultry industry on farms. Feed grinders suitable for hard corn in Kansas, for example, are not necessarily satisfactory for soft corn in Minnesota. Research is often conducted on a cooperative basis with electric utilities and with State Experiment Stations to save costs and to obtain nationwide results in testing equipment under a variety of conditions and crops. Industry maintains close contact with USDA research for information on functional requirements and performance characteristics for electric motors, equipment and controls; for example, the motor and control requirements for silo unloaders. The estimated annual industry expenditures for research on items specifically for "on-farm" use are believed to be approximately 10 man-years on poultry equipment, 10 on beef equipment, 10-15 on dairy equipment, 5-10 on swine and less than 5 on sheep equipment.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Environmental Requirements and Control for Poultry. Calorimeter studies at Beltsville, in cooperation with AH, were resumed after reassembling two calorimeters that were moved to the new AE Poultry Environment Laboratory. Each calorimeter was enclosed in a separate room for more precise control of temperature. Two special cages (with droppings pan underneath) were constructed to handle groups of all classes of poultry. One of these will be installed in each calorimeter to study birds using a common feeder and waterer. During the year a 24' x 40' addition was made to the Laboratory and within it five chambers (each 7 feet x 11 feet x 6 feet) were erected to study long-time effects of controlled environment on growth and egg production. The necessary wiring, piping, and installing of refrigeration and air handling equipment for environmental control is now in order.

Calorimetric data for caged White Leghorns were analyzed, published and successfully used to check studies of experimental windowless and solar poultry houses. The heat balance for windowless houses was within expected accuracy. For the solar house, however, a heat balance showed, at times, a heat output about 20 to 30 percent greater than heat input by the birds. Further studies are needed to assess in-place U values, infiltration, exfiltration, solar heat pick-up, and other factors.

Short-run heat and moisture production measurements were made on Arizona Short-Combed White Leghorns (heat resistant strain). These birds evaporated about 15 percent more moisture from lungs and/or bodies at 85° F. than the Beltsville-bred Short Combed White Leghorns.

Turkeys, in tests of one-week periods at temperatures of 65° F. and 80° F., had heat production rates, per unit live weight, that approached those of the New Hampshire x Cornish laying hens reported in ARS 42-43. During the lighted hours at 65° F. both toms and hens emitted about the same total heat. At night the toms and hens produced 25 percent and 10 percent less heat per pound, respectively, than the NHxC chickens. At 80° F., the toms and hens emitted about 10 and 20 percent less heat, respectively, per unit of live weight than the NHxC chickens. During the dark hours both the sexes produced 10 percent less heat per pound than the laying chickens.

Studies of the influence of temperature and ventilation on development of sinusitis in turkeys were conducted at St. Paul, Minnesota, in cooperation with the State station. In the first of 2 tests, one heated and one unheated pen, each with about 50 birds, were used; in the second test, two heated and two unheated pens, each with 80 birds, were used. Ten birds in each pen were inoculated with type S₆ PPL0 virus. In both tests the rate of natural transmission from inoculated to non-inoculated birds was nearly 100 percent as determined by PPL0 serum plate test. In the first test 20 percent of the inoculated and 3 percent of the noninoculated birds in the heated pen developed lesions that would have caused condemnation; corresponding data for the unheated pen were 33 percent and 11 percent. In the second test, 16 percent of the inoculated birds in the heated pen and 29 percent of those in the unheated pen were condemned. Data on the noninoculated birds are not available.

Plans for the poultry disease laboratory at Athens, Georgia, for which funds were appropriated in FY 1961, were prepared in cooperation with ADP, AH and the College Agricultural Experiment Station. The principal area of agricultural engineering responsibility is the relation of housing environment to poultry disease. Close assistance was given the architect in preparation of the laboratory plans. The contract for construction was awarded on February 12, 1962, and the project is to be completed in 365 days. Facilities include two buildings for environmental studies, one of which is to contain 12 environmental chambers.

Development and construction of these chambers is the responsibility of AE. Tentative designs have been prepared and a prototype is being constructed.

Field observations of poultry housing in Mississippi to develop data on the relationships of poultry house design, construction and management to airsacculitis, were initiated in February 1962, in cooperation with AH, ADP, and the State station. These studies are preliminary to preparation of final plans for the research program in the projected poultry disease laboratory at State College, Mississippi. No findings have developed as of the reporting date.

Typical plans for a stretched wire cage laying house for the Northeast and another for the Southwest were developed at Beltsville for the Cooperative Farm Building Plan Exchange.

Poultry Equipment. In Illinois a medium pressure (about 10 p.s.i.) ground feed conveying system has been under development. Although initial installations have been on poultry farms, the system is applicable to livestock using ground feed.

One change has been made in the conveying system on a cooperating farm during the past year. The rapid wearing of the diverter valve liners is still a problem. Feed hits the liner after it makes the 30-degree turn at the diverter valve. The valve liner wears out quickly in a small area. A 30-degree branch line diverter valve has been replaced by a 45-degree valve. The 45-degree turn will distribute wear more evenly over the liner.

A new auger-feed injector has been developed to replace the rotary air lock feeder valve previously used for getting the feed into the air line. The first successful model consisted of a 2-inch half-pitch horizontal auger force-feeding a vertical auger of the same type and size. Above the vertical auger was a tapered section of a cone that serves as the air lock. It acted as a one-way valve permitting the feed to move upward easily through the flared section with very little force required. At the same time, it prevented the escape of air back through the injector. The feed passed from the tapered section into a mixing chamber where it was picked up by the air and moved down the pipeline.

The two-auger feed injector has been modified to eliminate the vertical auger. The horizontal auger forces feed directly into a tapered 90-degree flared elbow. The feed is moving in a vertical direction when it enters the mixing chamber. This injector is simpler than the two-auger injector. The single-auger injector has been thoroughly tested in the laboratory and is ready for field testing.

Basic studies of the pressure drop for a range of air flow and feed rates through elbows in a 1-inch pipeline was limited to elbows of 6-, 9-, and 12-inch radii of curvature. Two 6-inch elbows, one of which was flattened $1/4$ inch; three 9-inch elbows, one of which was flattened $1/4$ inch, and one flattened $1/8$ inch; and two 12-inch elbows, one flattened $1/4$ inch, were investigated. The $1/4$ -inch flattened elbows generally had less pressure drop than either the round or $1/8$ -inch flattened elbows of the same radius. The 9-inch radius elbow again showed less pressure drop than either the 6- or 12-inch.

Pressure drops in two 50-foot straight sections of pipe were studied and compared to an equal length of pipe with an elbow included. The equivalent length of straight pipe for an elbow in the pipeline varied from about 10 to 30 feet depending on the amount of air and feed being conveyed. The equivalent length of pipe for an elbow was maximum at a feed-air ratio of 15:1 and decreased as either more or less feed was conveyed.

Poultry Environmental Equipment. Beltsville White turkeys were subjected to gradually increased day-length from maturity through one season of lay under normal and controlled environments. These basic studies in cooperation with the Poultry Branch, Animal Husbandry Research Division, are a continuation of length of photoperiod and abrupt versus gradual change in photoperiod. Starting with a natural day-length of about 9 hours in December, birds were subjected to 11, 13, and 15 hours. Day-length was increased for each group approximately 15 minutes at 2-week intervals until an 18-hour day-length was reached. There were no important differences in fertility and hatchability. Egg production was slightly more in the 13-hour group than the 11-hour group and also slightly more in the 15-hour group than in the 13-hour group. The average length of effective breeding season for all pens was 28 weeks.

Approximately one-half of each group was housed in conventional range houses with incandescent lamps supplementing natural daylight for day-length control. The remainder of the birds were maintained in a controlled temperature and relative humidity room ($65^{\circ} \pm 5^{\circ}$, and 70% relative humidity) with daylight excluded and light supplied by incandescent lamps. During the season of test the birds in conventional houses were subjected periodically to subfreezing temperatures and to moderate heat stress at the latter portion of the experiment. The 11-hour group in outside environment produced less eggs than comparable inside groups. However, the longer day-length groups showed little difference in performance due to environment. An article on this work has been accepted by the Poultry Science Journal for publication.

An electromechanical system for recording the time at which individual fowls lay eggs was assembled for trial use. A row of metal fingers (1-1/4 in. long spaced 1-1/2 in. apart) is mounted on a shaft over the egg trough of a battery cage. Each time an egg rolls under the fingers a mercury switch on the shaft revolves with the fingers and closes the circuit to a recording pen of an operational recorder. The marked operational chart then provides a record of the time a hen lays her eggs. One recorder serves 20 cages. In Georgia, a small facility for basic investigation of the effects of air movement (0.8) on growing chickens was designed, constructed, and placed in operation in Spring of 1960. Six trials have been conducted in the air movement facility, using broiler-type chickens approximately six to nine weeks of age. Five constant air velocities, ranging from 15 to 500 feet per minute, were maintained during each 2-week growth period. Air temperatures and humidities were the same for each velocity and were programmed to simulate a typical hot day cycle. As air velocity increased, growth rates and feed efficiencies increased and water consumption decreased.

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II. UTILIZATION RESEARCH AND DEVELOPMENT

POULTRY - PROCESSING AND PRODUCTS

Western Utilization Research and Development Division, ARS

Problem. The \$1.6 billion poultry meat industry is now operating on very narrow or negative profit margins. This industry is confronted with the problem of converting continually increasing amounts of poultry into a wide variety of products having high quality and improved convenience, at costs attractive to consumers and remunerative to the poultry grower. Information on the properties and processing characteristics of poultry is not sufficient to enable us to better utilize poultry in a variety of forms attractive to consumers. Increased utilization of poultry would also serve toward eliminating our feed grain surplus, increasing returns to farmers and providing better products for American consumers.

Although poultry is a highly efficient converter of feed to meat, more grain is used by poultry per calorie of food produced than by any other commercial animal because a high percentage of the poultry diet is grain and because poultry meat contains exceedingly little fat. Furthermore, one-fourth of all grain fed to animals is used for poultry and egg production. For these reasons, increased consumption of poultry products would be a highly effective means of providing increased markets for surplus grain. Also, the efficiency of feed utilization by poultry makes possible prices of poultry low enough to be within reach of increasing numbers of consumers. A still further benefit would arise from the increased use of poultry by improving the nutrition of consumers having diets now low in animal protein.

The consumption of poultry has steadily increased from 23 to 28 to 36 lbs. per capita for 1949, 1954, and 1959. This important increase has involved the factors: price, quality of product, availability, and disposable income. Because of the current low profit margin it is impractical to increase consumption by lowering farm prices. Increased demand for and consumption of poultry will require higher quality and more convenient products and a greater variety of them to meet the desires of the modern consumer. However, in addition to greater returns from increased demand, a greater profit margin for the farmer can, of course, come from greater efficiencies in processing.

The trend toward convenience foods and further processing has primarily involved the development of precooked poultry products, which are generally less stable, are subject to warmed-over flavors, and are more likely to provide texture problems than uncooked items. With the expansion in scale of operation and the emphasis on continuous, more efficient processing, need has arisen for improved

processing procedures for feather removal, chilling, tenderization, freezing, deboning, and commercial cooking. Lowering the cost and improving the quality of products that can be stored at ambient temperatures, such as canned, dried, cured, and irradiated products, offer further potential for poultry utilization in domestic and export markets. As a foundation for applied studies, further knowledge is needed on the chemical nature of flavor and flavor changes in processing and storage, on tenderness development, and on proteins, lipids, and other components in relation to processing and new products.

USDA PROGRAM

Basic and applied research on poultry meat and poultry meat products are conducted at the Division headquarters at Albany, California and, by contract, in East Lansing, Michigan. Fundamental studies on poultry flavor are concerned with the identification of flavor precursor constituents in poultry meat and in the isolation and identification of volatile flavor components developed during the cooking of poultry. The chemistry of muscle protein and post mortem chemical changes are investigated relative to the tenderness and other quality characteristics of poultry. The basic physiological character of feather release mechanism in fowls is studied to provide a foundation for improved feather removal. Applied research is conducted on the stability of cold-tolerant organisms; special problems of flavor, texture, and stability of precooked frozen foods; processing factors that influence tenderness of poultry meat; and, supported by transfer of funds from the Department of Defense Quartermaster Research and Development Command, preservation of poultry meat by use of ionizing radiation.

The Federal program of research in this area totals 13.9 professional man-years. Of this number, 7.6 are assigned to chemical composition and physical properties; 4.3 to new and improved food products (including 1 supported by transferred funds from the Defense Department); and 2.0 to new and improved processing technology.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported 14.5 professional man-years divided among subheadings as follows: chemical composition and physical properties 3.2, new and improved products 5.5; new and improved processing technology 5.6; and new and improved uses for feathers and other processing wastes 0.2. Fundamental studies are concerned with the effects of dietary factors on poultry meat quality, physico-chemical measures of changes in quality, and physico-chemical changes in poultry meat during post mortem period. Applied research is concerned with development of new frozen and otherwise

preserved poultry meat products and suitable outlets for less desired, bony parts. Processing studies include factors to reduce quality defects, shrink, and nutrient loss; improved freezing methods; and use of anesthetizing agents and their effects on blood loss, feather removal, and tenderness. A small amount of work is conducted on finding new and improved uses for feathers and other poultry by-products.

Industry and other organizations including processing companies, and equipment and packaging manufacturers conduct research programs that are principally concerned with specific applications to individual corporate problems. Such investigations are connected with the development of processing and raw material control methods, more efficient handling and processing procedures, prevention of quality defects and deterioration, new product formulations, and development of processing equipment and protective packages. The findings of such research is frequently kept confidential or protected by patents. The fundamental requirements of processing and packaging are developed in State and Federal laboratories and the development of equipment and packages to meet the requirements accomplished by industry research. Universities and non-profit research institutes conduct poultry research on a limited scale, often with contract or grant funds from public resources. Estimated annual expenditures in this area are equivalent to approximately 60 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Flavor Chemistry. Fundamental investigations on the chemistry of poultry flavor are conducted to provide information that can guide a rational approach to preservation of optimum quality of poultry meat products. Volatile components of cooked chicken and storage deteriorated chicken products are separated and characterized by gas chromatography. Correlations are sought with sensory evaluations. Decadienal has been identified as a principal volatile component, arising from the fatty portion of chicken meat during cooking. Synthetic decadienal, on exposure to air develops a stale and then a rancid odor. It is thus suspect as a precursor of these types of off-flavor. Rancidity developed in stored, frozen fried chicken was detected by organoleptic evaluations sooner than it could be detected by the gas chromatographic equipment available. As storage continued (8 and 10 months at 10° F.) chromatograms showed a very definite increase in amount and complexity of volatiles formed. More sensitive equipment is being constructed. Volatile carbonyls of cooked chicken have been isolated and characterized in previous studies. It has now been found that carbonyl compounds tend to accumulate in the fatty phase of the broth where their contribution to off-flavor is obscured.

Isolated carbonyls added back to the aqueous portion of the broth cause easily-detected off-odor. Broth flavor was adversely affected when acidity was decreased either by ante mortem injection of adrenalin or by cooking immediately post mortem. Increased pH resulting from both methods may be influencing flavor producing reactions during cooking.

Studies on the precursors of hydrogen sulfide, which is continuously evolved during the cooking of chicken, have indicated that it comes mainly from the proteins and only in minor proportion from small molecular weight sulphydryl compounds such as cystine or glutathione.

2. Effects of Production Factors on Poultry Flavor. Studies were conducted cooperatively with the Poultry Research Branch, Animal Husbandry Research Division, to determine differences in chicken flavor that might exist because of breed, feed, age, and sex of bird. Comparisons were made at age differences ranging from 6 to 78 weeks, and using several different cooking methods. In general, flavor differences were found to be small and probably of negligible practical importance. Since consistent, large differences were not found, it does not seem necessary to replicate such research with a range of age in the products under investigation.

3. Post Mortem Biochemistry and Tenderness. Fundamental research is conducted on the chemistry of protein change in poultry flesh following slaughter and the effect of chemical change on tenderness of cooked meat. Earlier studies indicated that rapid onset of rigor mortis was accompanied by increased rate of glycolysis and net disappearance of adenosine triphosphate, and associated with accentuation of toughness in young birds. Studies were conducted in which glycolysis was absent through chemical inhibition of a glycolytic enzyme, phosphoglyceraldehyde dehydrogenase, and by exhausting the muscle glycogen supply by ante mortem injection of adrenalin. Birds treated thus did not become tough, indicating that a rapid rate of post mortem glycolysis is intimately involved with toughness. Studies are continuing on factors that lead to different glycogen contents in slaughtered chickens and rates of post mortem glycogen disappearance. The extractability of muscle contractile proteins is being studied. Muscle from adrenalin-treated chicken differs from non-treated muscle in solubility characteristics immediately post mortem. While no change occurs during 24-hour aging of the treated muscle, the non-treated muscle changes and becomes quite similar in solubility characteristics to the other.

4. Physiology of Feather Release. The lack of fundamental understanding of the nature of feather retention and release limits major improvements in commercial feather removal. Contract research at Michigan State University has been conducted to conclusion of one phase of study and a new contract has been initiated to follow some

pathways indicated by the completed investigation. Gross anatomical and histological observations were made of the feather, its follicle, and associated muscle and connective tissues. Preliminary investigation of the role of the autonomic and central nervous systems in feather release was conducted, using selective physiologically active compounds. The effect of a slaughter method associated with feather loosening (brain sticking) was studied. Histological studies established the absence of previously postulated circular muscles around the feather follicles, and identified, in the connective tissue surrounding the follicle, elastic fibers which may play a role in feather retention. Data from slaughter tests and the effects of anesthetics pointed to a section of the brain (the medulla oblongata) as the critical area concerned with feather loosening. Selective action on feather release of a series of drugs implicated a functionally separate sub-system of the autonomic or involuntary nervous system. Atropine, which blocks the parasympathetic system, produced marked feather loosening, while tolazoline, which blocks the sympathetic system, had no effect. Other tranquilizers and anesthetic drugs were catalogued as to effects on feather loosening. With this good start, the new contract will be pursued to develop information on histological and biophysical differences between the tightened and relaxed states of feather follicles, the nature of the variation of constrictive force within individual follicles due to chemical and physical agents that may affect feather retention or release, and location of nerve centers that may control feather release.

B. New and Improved Food Products

1. Radiation Preservation of Poultry Products. For its potential value in feeding troops where refrigeration is not available, irradiation-sterilized poultry is considered potentially attractive. With funds transferred from the Department of Defense, studies were conducted to evaluate the usefulness of ionizing radiations in the preservation of poultry products. Irradiation-sterilization of meat and storage at non-refrigerated temperatures causes changes in its flavor, texture, and color. Experiments were conducted to extend knowledge of the problems in irradiation-sterilized chicken and to seek means of preventing or reducing adverse changes. An irradiation dose of 4.5 Mrads has been suggested for sterilization, and the odor and flavor induced by irradiation of chicken parts at room temperature were readily detected at a dose of 0.1 Mrad and increased with increasing dosage. Enzyme inactivation is essential in chicken and other meat to avoid very strong disagreeable flavor changes in subsequent storage. Irradiation of enzyme-inactivated chicken at sub-zero temperatures reduces the development of off-flavors. Packaging the chicken with a packet of adsorbing charcoal, cooking it in deep fat, and adding seasoning, further mitigate the off-flavor to the degree that negligible adverse reactions would be expected.

Irradiation-sterilized chicken develops an objectionable red color during storage at elevated temperatures in an inert atmosphere if it is not heated prior to treatment. Storage of irradiated chicken at elevated temperatures (room temperature and above) results in exudation of liquid and in a soft, disintegrated texture and dryness in the cooked product. This adverse condition is not controlled by heat treatment for enzyme inactivation and is the most serious remaining problem. Storage at temperatures between freezing and room temperature may help prevent this condition. Support of this research project by the Defense Department will continue at about the same level.

2. Precooked Frozen Foods. Research is conducted on development of the principles governing the behavior of essential basic ingredients that influence their suitability for use in prepared and precooked frozen foods. The peeling tendency of coatings of fried chicken is accentuated in the frozen product. Means of preventing or reducing this defect have been sought. The sequence of processing steps during preparation of fried chicken was found to be of primary importance to adhesion of the coating. Elimination of most of the moisture ordinarily lost during cooking prior to application of the batter produces a product with less tendency to peel than one in which the coating coagulates before the chicken undergoes the shrinking caused by cooking. Tests of the frozen storage stability of foods requiring maintenance of a gel structure were conducted. Simple gelatin gels are unstable below 20° F. Turkey meat loaves, raw and cooked before freezing, and lemon pie fillings are being developed to determine conditions necessary for a stable gel structure. Effects of formulation in connection with processing factors are being investigated. In addition, studies have been initiated on the frozen storage stability of foods whose distinctive character requires maintenance of a foam structure, such as raw or baked soufflés.

C. New and Improved Processing Technology

1. Low-Temperature Microbiology. Fundamental and applied research is conducted to determine growth, survival, and death characteristics of micro-organisms that grow at temperatures of about 32° F. and lower. An extensive review of the literature on low temperature microbiology was conducted, in cooperation with the research program on vegetables at the Western Regional Research Laboratory. The temperature limits of public health hazard and other findings of importance relative to the handling of frozen foods were delineated from published reports and disseminated widely at meetings of industry and public health officers. A temperature gradient incubator was constructed and its use in studies of various factors that affect growth of organisms at chill temperatures was initiated. This device is a practical research tool that determines with great accuracy the

temperature range of growth. Its use has established for a number of cold-tolerant organisms, that temperature of maximum growth is near 95° F. even though they will grow at subfreezing temperatures. No instance has been found in which an organism will grow better below freezing than above. The lowest maxima of this series of tests was a strain of yeast that had a maximum growth near 50° F. Frozen and thawed chicken parts were found to develop spoilage organisms at above zero holding temperatures no faster than parts that had not been frozen. Spoilage was significantly reduced if the parts were dipped for 30 minutes in cold, saturated brine prior to freezing but too much salt was added for good palatability.

2. Tenderness and Other Textural Qualities. The findings of basic research are extended to new and improved processing methods in laboratory investigations. Thus, with the implication of glycolysis in post mortem muscle changes, treatment of poultry flesh with chemicals involved in the glycolytic cycle is a rational approach. Polyphosphates, which occur abundantly in biological systems, play a critical role in glycolysis and were used to treat poultry by a dip in chilled solutions. Effects of this treatment were a change in color of raw product from the normal yellowish cast to a bluish white appearance and a decrease of about 4% in the cooking shrink. The cooked product was normal in appearance and test panels could detect no consistent difference in flavor, tenderness, or juiciness that was related to the treatment. Taste panel tests and objective chemical tests for rancidity made on cooked turkey meat indicated that polyphosphates, incorporated in the prior chilling step, had a stabilizing effect in refrigerated storage (about +40° F.) or in +10° F. frozen storage of the cooked meat. Tests have demonstrated that poultry meat frozen immediately after slaughter and then thawed and aged was less tender than that aged before freezing. The possibility that rate of thawing might be involved in this difference was investigated. Thawing rapidly (4 hours) or slowly (24 hours) had no significant effect on the tenderness of birds aged 3 to 4 days after thawing.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Chemical Composition and Physical Properties

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EGGS - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. The \$1.8 billion egg industry is periodically faced with burdensome surpluses that drive prices below the break-even point for many producers. The industry is also faced with a declining per capita consumption. Because eggs used as table eggs have a relatively low elasticity of demand, increased utilization of eggs must come primarily from development of egg-containing products that can compete more successfully on the basis of improved convenience and quality. Adequate knowledge is lacking of the properties, processing characteristics, and new product potentials of eggs needed to develop new markets. Increased utilization of eggs would not only benefit the producer, but would also serve toward eliminating our feed grain surpluses since poultry and egg production account for about one-fourth of all grain fed to animals. Improved egg-containing products would benefit the producer in three ways: by providing an increasingly useful buffer for stabilizing egg prices; by providing additional uses and outlets for eggs; and by providing more remunerative outlets for wholesome eggs that are unsuitable for table use because of appearance or handling characteristics.

Present outlets for the 10% of egg production that is frozen or dried include the baking, confectionery, salad dressing, noodle, and baby food trades. Modified and new products emphasizing quality and convenience are needed to increase acceptance of egg products by these industries and thus to compete successfully with egg substitutes.

At present, principal problems of egg processors exist in four areas. First, improvement in flavor stability, dispersibility, and freedom from pathogenic Salmonella bacteria are needed to realize the potential of yolk-containing solids in convenience foods. Second, improvements in useful properties and lessening of processing costs of egg white products are necessary to alleviate the imbalance and surplus that accumulates as a result of separation of eggs to satisfy the yolk demand. Third, further basic research on egg composition and components is essential to reach an understanding of physical and chemical changes induced by processing and storage and thus provide a rational basis for devising improved processes and products. Fourth, for direct implementation of egg product utilization, formulation studies designed to incorporate eggs into new household and institutional convenience products, are needed. The latter study must encompass a full appraisal of physical, chemical, and microbiological problems peculiar to the formulated products.

USDA PROGRAM

In the Western Utilization Research and Development Division, a broad program of basic and applied research is conducted at the Division headquarters at Albany, California; by contract in Austin, Minnesota; and by grant funds under P.L. 480 in France. Fundamental research is conducted on egg proteins and their relations to the functional properties and quality of eggs, on egg lipids and their role in off-flavor development in yolk solids, on the mechanism of bacterial penetration and survival in eggs, and on the bactericidal, antiseptic, anti-inflammatory, and food preserving properties of lysozymes and other components from eggs. Applied research is conducted on the stabilization of yolk-containing solids to increase the usefulness of eggs in dry mixes and other convenience foods, on new and improved drying procedures to make dried egg fractions and products more readily and more completely dispersible, on various methods of controlling Salmonella in eggs, and on factors in the handling of shell eggs that affect egg product quality and cost.

The Federal program of research in this area totals 13.3 professional man-years. Of this number, 6.9 are assigned to chemical composition and physical properties, 4.0 to new and improved food products, and 2.4 to new and improved processing technology.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations are conducting research on the chemical composition and physical properties of eggs at the rate of 5.5 professional man-years. The programs include a variety of studies on the basic composition of eggs, the nature of various egg proteins, chemical changes involved in thinning of egg white and other deteriorative processes, relation of various egg properties to functional characteristics, effects of bacteria on egg composition, and similar and related topics. About 0.8 professional man-year is devoted to new and improved food products on subjects such as utilization of under-grade shell eggs, new packaging techniques, factors affecting performance properties of eggs, and on antioxidants for food products containing egg yolk. About 0.6 professional man-year is applied to research on methods for preserving eggs, including studies on frozen egg products and enzymatic effects in yolk stabilization.

Industry conducts practically no research on the chemical composition and physical properties of eggs except as incidental to the development of new and improved products and processing technology. It is estimated that egg product manufacturers devote not more than the equivalent of 6 professional man-years to research on control of Salmonella in eggs, on improving performance of dried egg white, and on improving the efficiency of dried egg white manufacture. About 3 professional man-years are devoted to formulation and testing of new

convenience foods containing eggs. Research on improvement of washing, breaking and separating eggs, on improved heat pasteurization equipment, and development of chemical sterilization techniques is conducted at the rate of about 2 professional man-years. About 1 professional man-year is devoted to modification of feeds for laying hens to obtain uniformly deep yolk color in eggs.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Proteins. Light scattering studies have shown that ovalbumin in solution of pH 9 exposed to 95° F. for several days will fail to agglomerate normally when the solution is acidified. Additionally, the coagulation temperature of the ovalbumin in acid solutions is greatly increased. These results are in accord with a mechanism earlier indicated for inferior egg white performance in angel food cake following holding of shell eggs at elevated temperatures.

Work on the possibility that bound cysteine in the yolk is released and translocated into the white, thereby contributing to egg white thinning, was continued. A more efficient recovery method involving dialysis and bromine oxidation for eventual recovery of cysteine-cystine as cysteic acid was developed and applied. Present results, although inconsistent, indicate no measurable cysteine-cystine in the whites from fresh shell eggs. However, when shell eggs are held for several days at 75° F., the bound cysteine decreases in the yolk and increases in the white. No quantitative correlation has, however, been attempted between the translocation of cysteine and egg white thinning.

The use of cellulose column chromatography as a preparative procedure was developed. Several purified egg white proteins were prepared directly from bulk quantities of white, including lysozyme, 3 conalbumins, ovomucoid, 3 ovalbumins, 3 flavoproteins, and a pink protein, possibly a nucleoprotein. The procedure greatly shortens the time required for obtaining isolates and is sharply definitive, and is applicable to the preparation of fairly large quantities (10 grams) of specific components.

Under a research grant to the University of Paris, France, supported by P.L. 480 funds, a project was initiated on lysozymes from various sources, including egg. The objective is to elucidate the relationships between chemical structure and biological activity of lysozymes from various sources as a basis for understanding and utilizing the bactericidal, antiseptic, anti-inflammatory, and food preserving properties of these enzymes. Progress includes a new and effective way of separating and purifying lysozymes, determination of the

sequence of amino acids in egg white lysozyme, and development of a method for studying the enzymatic activity and the specificity of lysozymes using a soluble substrate of these enzymes from Micrococcus lysodeikticus.

2. Lipoproteins. Emulsifying and foaming properties of egg yolk are known to be largely dependent upon the characteristics of the yolk proteins. Previous investigations of yolk proteins, employing combinations of salt fractionation and ether extractions, failed to yield the homogeneous fractions of yolk lipoproteins needed for correlation with functional characteristics of egg solids. Research was undertaken on ultracentrifugation for separation of yolk proteins. Fractions obtained by simple ultracentrifugation of yolk were further separated by ultracentrifugation of various salt solutions of the fractions. In general, the technique did not yield satisfactorily homogeneous fractions and does not appear to be applicable to high-lipid substances such as egg yolk.

3. Fatty Acid Composition of Yolk Lipids. The major fatty acids of egg yolk lipids of hens raised on a typical commercial dietary regime were found to consist of oleic, palmitic, stearic and linoleic acids. The relative amounts of these acids were comparable to previously reported data with palmitic and oleic making up over 75% of the total. Palmitoleic ($C_{16}, 1=$), arachidonic ($C_{20}, 4=$), docosohexaenoic ($C_{22}, 6=$) and docosopentaenoic ($C_{22}, 5=$) were also detected in minor amounts, and at least twelve other fatty acids, some having branched or odd chains, were detected in trace amounts. Among these, the following were identified: $C_{20}, 2=$; $C_{20}, 3=$; $C_{20}, 5=$; and isomers of the docosohexaenoic and decosopentaenoic fatty acids reported above. Arachidonic, docosohexaenoic and docosopentaenoic acids were isolated in highly purified form.

The total lipids consisted of 69.5% triglyceride, 21% phospholipid and 9.0% minor constituents. At least eighteen components were detected in the minor constituents with carbon numbers from 12.8 to 28.6 as determined by gas-liquid chromatography. However, except for palmitoleic, palmitic, oleic and stearic acids, these occurred in only trace amounts. The triglyceride fraction (69.5% of total lipid) contained 12 different fatty acids with palmitic and oleic making up 83.4% of the total and stearic and linoleic accounting for an additional 13%. The distribution of saturated (S) and unsaturated (U) fatty acids in the triglycerides (G) as determined by a newly developed method was as follows: 1.7% GS_3 , 14.1% GU_1S_2 , 34.7% GU_2S , and 49.5% GU_3 .

About 85% of the total phospholipid consisted of cephalin. However, at least three other components were detected in this fraction. The polyunsaturated fatty acids containing more than two double bonds

were nearly all in the phospholipid and the C₂₀ and C₂₂ polyunsaturated acids represented about 5% of the total. The ratio of unsaturated to saturated fatty acids in cephalin was close to 1:1, but small amounts of both diunsaturated and disaturated components were also detected.

As the result of this research, the polyunsaturated fatty acids were identified, and their distribution in egg lipid fractions was determined. Since the oxidative decomposition of these acids, in their particular fractions, is undoubtedly a principal factor in off-flavor development, their identification provides a basis for study of the oxidative mechanisms involved.

4. Oxidative Changes in Yolk Lipids. Research was initiated on oxidative changes in yolk lipids as related to off-flavor development. Two volatile decomposition products were found to develop during air storage of yolk-containing egg solids. Further analysis showed that the two products arose from the phospholipid fraction. Surprisingly, infrared spectra of the products showed practically no evidence of carbonyl groups. Analysis of volatiles from sugared yolk-containing egg solids which had undergone oxidative flavor deterioration revealed large amounts of a foreign component which had previously been detected in lesser amounts in the volatiles from unsugared, egg-containing powders stored in air. The component has not yet been identified.

A special type of chromatography applied in the separation of lecithin and cephalin disclosed a new component in the phospholipids of air-stored egg powder. The component was extremely unstable and decomposed rapidly in vacuo. It is postulated that the new component is a precursor of off-flavors and odors.

Cephalin isolated from egg yolk was found to autoxidize much more rapidly than lecithin or highly unsaturated model systems such as methyl docosohexaenoate. Model system studies also showed that egg lecithin has a pronounced effect on reducing oxygen uptake by methyl linoleate, but that cephalin had a pro-oxygenic effect, even though the cephalin was fully hydrogenated to reduce its own contribution to oxygen uptake.

5. Bacterial Spoilage of Shell Eggs. Previous studies have shown that most egg spoilage bacteria are unable to multiply in unsupplemented egg white at its usual storage pH of 9.2. Studies were made, therefore, to determine the mechanism by which eggs spoil bacteriologically. Eggs were experimentally inoculated with various egg spoilage bacteria and then stored at 55° F. Population counts were made on the shell membrane system, on the white, and on the yolk at periodic intervals. Results indicate that the spoilage bacteria

multiply extensively in the shell membrane system before any invasion of the egg contents occurs. Subsequently, there is an increase in bacterial numbers in the white followed by growth in the yolk. This suggests that bacterial spoilage of eggs in storage may be controlled if storage conditions are selected to minimize or eliminate growth of bacteria in the shell membrane system.

Earlier laboratory studies showed that the presence of soluble iron in wash water greatly influences the rate and extent of spoilage of shell eggs by Pseudomonas. Similar results were found with other common gram-negative egg spoilage bacteria including Proteus, Alcaligenes, Aerobacter, Paracolobactrum, Achromobacter, and Salmonella. The effect of iron in wash water for shell eggs in increasing Pseudomonas spoilage has been demonstrated under actual ranch conditions. Thus, on one ranch with no previous history of "green rot" trouble, raising the iron content of the wash water from 0.4 to 10 ppm increased the rots detected after 48 days' storage at 55° F. from 0.8 to 2.5%. On a second farm where a serious spoilage problem existed, replacing the high iron wash water (4.8 ppm) with one of much lower iron content (0.2 ppm) decreased the incidence of rots from 6.2 to 0.8% after a similar storage period.

B. New and Improved Products

1. Mixtures of Carbohydrates and Yolk-Containing Solids. Studies on the stabilization of yolk-containing solids against oxidative flavor deterioration were completed. It was shown that carbohydrates, i.e., sucrose and corn syrup solids varying in degree of dextrose equivalent, provided good stability when added to yolk-containing egg solids. In fact, results showed that for every type of yolk-containing solid of commercial import, it is possible to achieve a good combination of flavor stability, performance value and stability, and sweetness by selection of type and level of added carbohydrate. Amount of carbohydrate to be used is critical. With increasing levels of carbohydrate, a point of maximum flavor stability was reached, but at slightly higher levels, abrupt and marked flavor instability was found. For various carbohydrates, the levels at which maximum flavor stability and instability were observed were found to be related to the average molecular size of the particular carbohydrate. Additionally, the levels of added carbohydrate yielding optimal flavor stability were correlated with the state of emulsion in the powder. Retention of the fat in a finely dispersed state led to marked flavor instability.

In the course of the research on yolk-containing solids, it was found that one reason for the variability of spray-dried yolk lies in the extent of protein alteration induced by processing. The protein alteration may be induced at three stages: (1) during preheating of the liquid prior to drying, (2) during high-heat spray drying, and

(3) during storage of the product at high temperatures. Analytical methods were developed for appraising the extent of protein alteration.

C. New and Improved Processing Technology

1. Control of Salmonella in Egg Whites. After preliminary screening of 28 bacterial strains for their usefulness in deglucosing egg white prior to drying, six were selected as the most promising and were examined over a wider range of nutritional conditions. Those selected were A. aerogenes B 199, E. coli. H 23, S. lactis E 71, S. cremoris B 634, L. mesenteroides B 641, and Ped. cerevisiae B 1345. E. coli. H 23 is an organism having additional value in being inhibitory to Salmonella. Of these organisms, only L. mesenteroides B 641 deglucosed egg white satisfactorily at pH 5.0 but required nutritional supplementation. It was then considered that fermentation at low pH might be of value in controlling Salmonella development. In further studies, it was found that three additional organisms, M. freundenreichii B 2354, S. lactis B 633, and L. casei B 442 would also deglucose whites satisfactorily at pH 5.0 providing acidification was made with citric acid and the egg white was supplemented with low levels of yeast extract and casein hydrolysate.

Tests made with one strain, Salmonella typhimurium TMI, have shown that in pure culture in egg white, the organism grows out well over a pH range of 5.0 to 7.0. In mixed culture, it grew out competitively at pH 7.0 with several of the above organisms, but was unable to compete at pH 5.0 with L. mesenteroides, M. freundenreichii, or S. lactis. The latter organisms multiplied normally and in doing so appeared to exert a bacteriostatic effect on the S. typhimurium. Low pH fermentation of egg white appears to have potential value in controlling Salmonella.

2. Effect of Age of Layer on Egg Quality. It has been previously reported that eggs from older layers, though exhibiting defects as table eggs, are advantageous for conversion to egg products because they yield a substantially higher percentage of their total content as yolk. Price considerations are such that the total value of the contents of eggs from older layers would be 10 to 15% greater than that from younger layers. These findings have been confirmed with eggs from two different White Leghorn strains. Additionally, it has been found that performance value of yolks from older layers as evaluated in sponge and layer cakes is equivalent or slightly superior to that from younger layers. The egg whites from older layers, however, have been shown to be low in solids and to yield angel food cakes with volumes consistently lower by 3 to 4% than those obtained with whites from younger layers. The difference decreases with holding of the shell eggs and is not apparent two to three weeks after lay.

The relative value for table and breaking stock of eggs from layers uniformly forced into their second year of lay by a controlled "force molting" process was appraised with a flock of approximately 15,000 layers. The birds were all of the same hatch date and were forced into molt at 21.5 months of age. The study was carried on for 8 months after molting. Results suggest that egg quality as measured by internal albumin quality, uniformity thereof, and shell strength is satisfactory for table grade eggs only for about the first three months of the second year of lay. After this time, the eggs resemble those laid at the end of the first year of lay and, similarly, offer particular advantages for egg breaking stock such as size, yolk yield, and yolk solids content.

3. Improved Dispersibility of Dry Egg Products. Further progress was made on the development of a modified spray-drying procedure for yielding instantly dispersible yolk-containing solids. A carbonating device was designed, constructed, and tested successfully in a 24-foot commercial pilot dryer. The product possessed excellent initial quality as well as dispersibility and is presently being compared with instant products made by agglomeration and by hot air drying of mechanically preformed foams. These studies are continuing.

Instantizing methods have also been applied toward improvement of the dispersibility of dried egg whites. Drying techniques other than conventional spray drying show promise. Spray drying of larger particles, gas impregnation of the white prior to spray drying, forced air drying of mechanically preformed foams, and agglomeration are all helpful, but in some cases only where carbohydrates have been added or when the whites have been concentrated prior to drying. In general, egg white, despite the absence of lipids, is more difficult to instantize than yolk-containing products.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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^{1/} Research conducted under P.L. 480

III. MARKETING RESEARCH

POULTRY PRODUCTS - MARKET QUALITY
Market Quality Research Division, AMS

Problem. New technological developments in the poultry industries have created many problems relating to the market quality of poultry and egg products. The introduction of highly mechanized equipment and new techniques in processing have had variable effects on the absorption and retention of moisture of ready-to-cook poultry, on the contamination of poultry and egg products by spoilage microorganisms, on physical damage to poultry carcasses, and on sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more precise information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

USDA PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, and at Athens, Georgia, in cooperation with the Georgia Experiment Station and through a research contract with the University of California, Davis, California, on the effect of various disease syndromes on the wholesomeness of market poultry.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years, about equally divided between objective measurements and evaluation of quality, and handling and packaging. Studies on the use of paper containers for ice-packed poultry (BS 2-39) and the contract study of disease agents in dressed poultry (BS 3-65) were terminated during the period.

A P.L. 480 grant with The Ministry of Agriculture, Spain, provides for a study of the relation of changes in chemical and biological properties of lysozyme to changes in quality of shell eggs held in cold storage. Its duration is for 3 years, 1960-1963, and involves P.L. 480 funds with a \$17,094 equivalent in Spanish pesetas.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Stations in 1961 reported a total of 6.1 professional man-years divided as follows: Objective measurements and evaluation of quality 1.9, handling and packaging 2.7, storage 1.4, and transportation 0.1. Under objective measurements and evaluation of quality are studies on yolk lipids and albumin constituents, odor absorption, and taste panel evaluation of desirability of eggs in relation to the quantity of lipids in the yolks. Handling and packaging include packaging materials, techniques for handling and applying films including edible forms. Storage work includes effects of storage conditions, of slaughtering, and of freezing methods, sanitation procedures, identification of microorganisms responsible for spoilage and methods for their control.

Industry and other organizations conducting research on poultry products include several firms manufacturing convenience food items that are investigating factors affecting the quality of poultry meat. Their estimated annual expenditures are equivalent to approximately 5 professional man-years. A few chemical companies are engaged in the formulation of chemicals or production of bacteriostatics to retard decline in quality of poultry meat and to minimize microbial spoilage and deterioration of quality of shell eggs. Estimated annual expenditures are equivalent to approximately 5 professional man-years. The various poultry industry associations, such as the Institute of American Poultry Industries, the Poultry and Egg National Board, and the National Turkey Federation, support research on quality evaluation and maintenance of poultry products. Estimated annual expenditures are equivalent to approximately 5 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality1. Assessing the Sanitary Quality of Commercial Egg Solids.

During the past year, work was continued in an effort to establish a sound basis for using the Group-D streptococci (enterococci) as indicators of the sanitary quality of egg products. Samples of egg white solids from the USDA laboratory in Chicago, as well as several samples from commercial firms were examined for coliforms, salmonellae, enterococci, and total viable bacteria. Results of these tests indicated that the enterococci were the predominant

organisms in these samples. Identification of a number of isolates from the enterococcus plates indicated that Streptococcus faecalis var. liquefaciens is the most common contaminant of these products. The enterococci were found to be most consistently resistant to the laboratory drying process. Work was also carried out to improve methods for the direct microscopic count (DMC) of bacteria in egg products. Modifications of the Moats' stain which utilizes periodic acid, bisulfite solution, and toluidine blue (PBT stain), developed for use with dairy products, was found to produce a better color differentiation between bacteria and egg melange. These modifications were necessary to compensate for the differences in viscosity of milk and egg products. Further work along this line is necessary before a completely satisfactory stain is developed.

(MQ 3-31)

2. Relation of Lysozyme to Egg Quality. Microbiological and chemical studies of shell eggs held in cold storage for various periods of time were carried out under a P.L. 480 grant.

Results obtained indicate that shell eggs stored at 0° C. and 90% relative humidity for periods up to 60 days were contaminated primarily with yeasts and molds, with no evidence to indicate the presence of bacteria. In accelerated deterioration tests it was found that (a) the rate of thinning of buffered egg white (pH7) was greater than that of unbuffered, (b) viscosity of egg white decreased with time concomitantly with an increase in the percentage of thin white, these changes being more pronounced in buffered samples, (c) lysozyme activity was higher in buffered eggs than in unbuffered, (d) lysozyme activity decreased slightly with time, and (e) two zones of maximum lysozyme activity appear (pH6 and pH8.4).

(E 25-AMS-5(a))

3. Antemortem and Postmortem Inspection Studies. This study to ascertain the quantitative and qualitative spectrum of infection of dressed poultry by human pathogens and to evaluate the efficacy of antemortem inspection as a supplement to postmortem inspection of poultry was completed this year.

Previously unreported results of the study are (a) a general relationship was found between condemnation rate and quality of overall husbandry practices in chicken fryer and turkey flocks; (b) the tissues of market poultry being routinely processed for

human consumption harbor coagulase positive staphylococci, coagulase-negative staphylococci, beta, alpha, and gamma hemolytic streptococci, Pseudomonas sp., Coliforms, Proteus sp., and Bacillus species at various incidence levels; (c) tissues did not contain the following pathogens; Brucella sp., Erysipelothrix rhusiopathiae, Listeria monocytogenes, Pasturella multocida, Clostridium perfringens, Salmonella sp. or Paracolonobacterium arizonae; (d) the intestinal contents of such poultry harbored Salmonella species and/or Paracolonobacterium arizonae contaminating unknown numbers of carcasses during processing. (e) Evidence was obtained which indicated a positive correlation between the gross pathology of chicken fryers and the presence of Salmonella species in the intestinal tract as well as the presence of coliforms in the liver of adult chickens; (f) no correlation was found between gross pathology of livers of chickens and turkeys and the presence of pathogens in the liver tissue; (g) some evidence was obtained to indicate a positive correlation between gross pathology of such a nature and extent as to be cause for condemnation of livers of chickens and turkeys, and the presence of some form of histopathology; (h) no correlation was found between the presence of specific pathogens and the presence of specific histopathology lesions in livers of chickens and turkeys. In addition to the above, a quantitative study of Salmonellae in the intestinal tract of market poultry yielded evidence indicating that the feces of turkeys artificially infected within the previous 6 weeks may contain up to $10^{3.5}$ Salmonella organisms per gram. This gives some concept of the possible magnitude of the contamination potential such birds would yield if processed.

(BS 3-65)

4. Effect of Various Disease Syndromes on Wholesomeness of Market Poultry. This study was initiated this year under contract with the University of California. Data to be developed during this study will aid in determining the relationship of the visible lesions which must be used by poultry inspectors to the various stages of the disease syndromes most commonly found in poultry and should result in more clearly defined criteria for judging the wholesomeness of market poultry.

(MQ 3-22(c))

5. Evaluation of Bone Darkening in Fryer Chickens. Darkening of bones, after cooking, has been an important factor affecting the consumer acceptance of frozen fryer chickens. A study was initiated to compare the incidence and degree of bone darkening of

frozen and unfrozen fryers and to develop practical methods for evaluating this defect. Thigh bones from cooked chickens (both frozen and unfrozen) were evaluated for intensity of bone darkening by visual comparisons of the bones to a series of nine Munsell chips ranging, in value, from white to black. Photographs of the individual bones were also taken in preparation for further studies to develop practical methods for rating bone darkening. The chickens, which had been reared on diets containing various levels of calcium and phosphorus, were obtained through the cooperation of the Poultry Branch, AHRD.

The extent and intensity of bone discoloration was greater in thighs which had been frozen and thawed before cooking than in cooked unfrozen thighs, although the difference was small. For both frozen and unfrozen thighs, there was a direct relationship between the calcium-phosphorus ratio and the severity of the bone discoloration.

(Exploratory work - no line project)

B. Quality maintenance in handling and packaging

1. Quality Changes of Ice-Packed Poultry in Paper Shipping Containers. Bacteriological evaluations were made of whole and cut-up chickens shipped in corrugated paper shipping containers and wirebound crates. Numbers of mesophilic and psychrophilic bacteria on poultry in corrugated paper containers were similar to those on poultry packed in wirebound crates after shipping about 150 miles and storage at 34° F. for 12 hours. Lining either the inside or coating the outside of a corrugated container with aluminum improved the container's insulating properties only slightly. Use of a kapok liner was more effective for inhibiting heat transfer.

Work on this project was terminated because of the unavailability of corrugated fiber containers which can stand up under laboratory storage tests.

(BS 2-39)

2. Influence of Polyphosphates and Other Compounds During Chilling on Quality of Eviscerated Poultry. A study of the effect of phosphate treatment on carcass weight changes and organoleptic quality of cut-up chicken was completed. Moisture uptake by eviscerated broilers during a 6-hour chill period in slush ice containing 7, 8, or 10 ounces of phosphate per gallon was,

respectively, greater than, no different from, and less than that by birds chilled in solutions containing no phosphate. Phosphate treatment reduced weight loss of cut-up carcasses during storage, resulted in an increase in juiciness of dark meat, and an increase in tenderness of white meat but did not significantly affect flavor.

(MQ 2-41)

The influence of a number of variables on the moisture changes in fryer chicken carcasses during chilling in the presence of polyphosphates and other compounds was also investigated. The effect of temperature and pH of coolant, duration of chilling, period of air agitation of coolant, method of chilling, concentration of phosphate mixture, and concentration of NaCl on moisture absorption and retention were determined. Analysis of the data is in progress.

(MQ 2-10)

3. Bacteriological Studies of Commercial Poultry Processing. A study to determine the effect of different cooling methods on the bacterial condition of fryer chicken carcasses was completed. Numbers of bacteria per milliliter of chill water increased significantly during 6-hour standard tank chilling (non-agitated). Bacteria counts of breast skin surface increased significantly during standard tank chilling, did not change significantly during chilling in an oscillated-vat, low agitation continuous chiller, and decreased significantly during chilling in a counter-flow tumble, higher agitation continuous chiller.

(MQ 2-10)

A survey of bacterial contamination during cutting and packaging of chicken fryers at retail stores and in commercial plants was completed. Total bacterial counts on uncut chicken were low in both plants and stores, but increased approximately sixfold in plants and eightfold in stores during cutting and packaging. Continuous spray washing of conveyor belts with chlorinated water in plants, thorough cleaning of meat blocks in stores, and the presence of adequate hand-washing facilities in both locations were the most important factors in preventing bacterial-buildup on cut-up parts.

(MQ 2-41)

A preliminary study of airborne bacteria in the atmosphere of poultry processing plants was carried out. In one plant, the

dressing areas were the most heavily contaminated. A more thorough study of airborne microorganisms is underway.

(MQ 2-6)

4. Basic Studies on Cooling of Eviscerated Poultry. Two studies were carried out in cooperation with the Transportation and Facilities Division. In one, the thermal conductivity and density of muscle and skin tissue of broilers and hens were measured to obtain basic data needed in the design and evaluation of poultry chilling equipment. No significant effect on thermal conductivity was produced by variations in percent moisture, percent fat, or weight of carcasses from which samples originated. The other study involved the determination of the rate of cooling chickens in 32° F. water. During this study a technique for thermocouple placement in broiler carcasses was developed that resulted in greater accuracy during recording of carcass temperatures. This study has been completed and a manuscript is being prepared for publication.

(MQ 2-41)

PUBLICATIONS REPORTING RESULTS OF USDA AND
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POULTRY AND EGGS - MARKETING FACILITIES,
EQUIPMENT AND METHODS
Transportation and Facilities Research Division, AMS

Problem. A rapid increase in the production of poultry and eggs in the United States in recent years and an accompanying increase in total consumption has resulted in significant changes in marketing methods and requirements for these products. These changes have had an impact on poultry processing plant facilities and equipment requirements, as well as in operating methods. Problems in this connection generally have been worked out by industry on individual plant basis. In the main, the answers have furnished only a temporary solution to expansion needs and little help in developing guidelines for new plants or solving production problems. In order to improve operating efficiency in existing facilities, and provide guidelines for plant expansion or for new facilities, with due consideration for product quality; more efficient work methods, plant layouts, devices and equipment and improved facility designs are needed for the commercial handling, processing, and packing of poultry and eggs to increase labor productivity, reduce nonlabor inputs, improve yield without lowering quality, and minimize construction and maintenance costs.

USDA PROGRAM

The Department has a continuing long-term program involving engineers and marketing research analysts engaged in both basic and applied research to develop more efficient work methods, techniques, operating procedures, devices, and equipment and to design improved facilities for the handling and preparation for market of poultry, eggs, and egg products. Research conducted in poultry processing plants by Department personnel at Athens, Ga., is cooperative with the Georgia Agricultural Experiment Stations. Contract research to develop improved poultry processing equipment is conducted by the Gordon Johnson Company at Kansas City, Mo. Department personnel in the Washington office conduct research relating to shell eggs and the design of warehouses for poultry and egg wholesalers. Contract research on shell egg cleaning techniques and equipment is conducted by the University of California at Davis, Calif.

The Federal effort devoted to research and development work in this area totals 5.7 professional man-years annually; 2.6 man-years (including 0.6 man-year of contract work) on poultry, 1.1 man-years (including 0.9 man-year of contract work) on shell eggs and egg products, 0.5 man-year on joint poultry and egg work, and 1.0 man-year on program leadership.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

About five of the larger poultry and egg processing equipment companies provide engineering services for developing plant layouts for firms interested in purchasing their respective lines of equipment. The work is done on a plant by plant basis without service charge if the request involves a firm order for equipment. Several of these firms are initiating research and equipment development work. Prototypes of experimental equipment constructed in their shops are tested in commercial plants under actual operating conditions to determine commercial feasibility, operating weakness, compliance with Department requirements, and industry acceptance. The results are generally confidential until such time when they can be used for product publicity. Estimated annual expenditures are equivalent to approximately 30 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Methods, Equipment, and Facilities for Grading and Packing Eggs

This research is directed toward reducing egg marketing costs through engineering analysis of existing work methods, equipment, and facilities for handling, cleaning, grading, shell treating and packing eggs and by developing and testing improvements. The work on developing and commercial testing of a mechanized egg grading, sizing and packing line was completed with the publication of the report "Automatic Sizing and Packaging of Eggs." Tests showed that the line offers a potential saving to industry of about one and a half million dollars annually.

A study evaluating commercial egg grading and packing systems was continued and expanded by the inclusion of the latest mechanized systems. A comparison of labor and equipment requirements for each selected line is being undertaken. Although field studies have been completed, the analysis of data has not progressed to the point that significant findings can be summarized.

Research to develop improved designs for commercial egg grading and packing plants was completed with the publication of the report "Improved Designs for Commercial Egg Grading and Packing Plants." Based on an engineering analysis of typical U.S. egg grading and packing plants, guidelines for building designs and plant layouts for operations of various production levels were developed. The report includes a layout for small egg breaking room and a three step plant expansion program from a small manual grading and packing operation, involving 62,500 cases of eggs per year, to a large mechanized operation, handling up to 275,000 cases annually. During the reporting period these guidelines were successfully applied to Australian conditions in response to a special request from that Government.

B. Improved Designs for Wholesale Poultry and Egg Distributors' Warehouses

This research involves an evaluation of the warehouse facilities, layout, and equipment problems of wholesale poultry and egg distributors in four large metropolitan areas and the design of improved facilities. Findings disclosed that facilities in use were not designed to handle the service being rendered and because of the age and building construction, installation of improvements calling for drastic modification to meet present day specialized service requirements are not feasible. Engineering designs and layouts are being prepared for multiple occupancy facilities capable of handling combinations of operations involving shell egg grading and packing as a principle operation and egg breaking and freezing facilities as an auxiliary operation, or handling frozen and icepacked poultry, including cutting-up and packing ice pack poultry as a principle operation and grading and packing small lots of shell eggs as an auxiliary operation. These layouts would not involve major modifications in the type of structure recommended for food terminal centers. These designs and layouts also would be applicable to a conventional detached structure, thus permitting both a choice as to location and a choice of the combination of services to be offered.

C. Improved Methods, Techniques, and Equipment for Cleaning Eggs

This research, carried on under contract with the University of California, involves the development of methods, techniques, and in-line equipment that will do an effective job of cleaning shell eggs with minimum quality deterioration and breakage and with a minimum of labor inputs. The practice of wet cleaning eggs destined for table consumption has increased at a rapid rate throughout the United States. The methods, techniques, and equipment now employed are costly in labor and breakage, high in egg spoilage hazard, and do an ineffective job of cleaning.

Laboratory tests determining safe time and temperature differences required between the temperatures of the egg and the washing medium have been completed. Findings show that a 20° F. temperature difference is necessary to reduce spoilage hazard to a minimum. The findings also verify a recent study showing that spoilage rates increase sharply when trace quantities of free iron occurred in the washing media. A technical paper reporting these findings has been submitted for publication. A number of commercial egg cleaners have been field tested. Results show that none of the cleaners do an effective job of cleaning, several induced eggs spoilage, and others cause an excess amount of breakage.

An analysis of these results, established a realistic objective for the selection of an effective cleaning technique and guidelines for the structural requirements of an efficient in-line cleaner. Working

drawings of an experimental in-line egg cleaner were submitted and approved, and major construction work has been completed. Tests to determine optimum line and component speeds, rapid simple methods for testing for trace quantities of iron, economical methods of de-ironizing the cleaning media, combinations of detergents, wetting agents and bleaches, and air temperature and velocity for drying the shells were underway at the end of the report period.

D. Improved Methods and Equipment for Eviscerating Chickens

This long-term research program, at Athens, Ga., involves the development of methods, operating procedures, and equipment for eviscerating chickens. Studies evaluating work methods and equipment and determining labor requirements for the eviscerating operation in plants under official U.S.D.A. inspection were carried out through use of micromotion time study and other industrial engineering techniques improvements in work methods, equipment and work station layouts were developed. The results reported in "Methods and Equipment for Eviscerating Chickens" showed that efficiency can be increased by: (1) Adopting work methods that avoid frequent loss of small quantities of edible product; (2) improving work station layout so as to permit higher productivity per worker with less fatigue; and (3) balancing crew size with the speed of the production line.

Operations in most plants involve different processing rates for the various steps in preparing the product in ready-to-cook form and require frequent manual transfer of birds between production lines operating at different speeds. This not only requires much additional labor, as many as 8 or 10 workers in large volume plants, but also creates serious production bottle necks which slow down or stop some operations altogether from time to time. A monorail conveyor capable of operating at different line speeds simultaneously, through the use of the power-free principle and intermittent storage loops, appeared to be a means of reducing these inefficiencies.

Due to machining inaccuracies on some of the test components, extended trial runs on an experimental power-free line were not feasible. With the correction of these defects trouble free operation appears to be possible, and should eliminate a number of production bottle necks and much labor auxiliary to processing operations.

E. Improved Methods and Equipment for Cutting Up and Packing Chickens

In packing chicken parts to an exact premarked package weight, much time is presently wasted in selecting the last piece of chicken to fill a container because the choice is made on a trial and error basis. Frequently, excess weight is packed in a container because a chicken part of the desired weight is not readily available. Research was initiated in this chicken processing area for the purpose of

reducing the labor requirements and the losses due to packing errors. In order to effect this reduction and also minimize product contamination by frequent rehandling, mechanical sorting by parts weight is being studied together with the entire cut up operation. Studies in the relationship of carcass size to the weights of an individual part and evaluation of a number of cutting up and parts packing operations were carried on in a number of plants in order to develop criteria for preparing contract specifications for a research contract for the designing, construction, and testing of a mechanized sizing and packing line. Under a contract with the Gordon Johnson Company, design drawings have been approved and construction of an experimental mechanized chicken parts packing line was nearing completion at the end of the report period.

A manuscript on the relationship of chicken carcass weights to parts weights has been completed. Using data from the report, processors will be able to predetermine the most desirable carcass size of chickens yielding the best combination of parts weight for a given container net weight.

F. Improved Designs for Chicken Processing Plants

The rapid growth of the poultry industry has resulted in building additions and frequently makeshift construction without sufficient regard to or utilization of space. New structures have frequently included errors in building design and plant layout because of an absence of basic guidelines. This research involves the development of guidelines for improved plant designs and layouts, furnishing maximum efficiency at minimum cost for new construction or alteration. Plant designs, layouts, and plant operating conditions in a number of large chicken processing plants were studied, evaluated and checked against facilities meeting U.S.D.A. inspection requirements. Findings developed in previous Department studies involving equipment layout for packing and eviscerating operations plus information from engineering textbooks and other publications on plant layout practices are serving as aids in screening out inefficiencies and undesirable features. A manuscript covering overall layout requirements, the layout of each work area and development of a plant design directed toward efficient operation and economic expansion has been started.

PUBLICATIONS REPORTING THE RESULTS OF U.S.D.A. AND COOPERATING RESEARCH

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CONSUMER PACKAGES AND SHIPPING CONTAINERS
Transportation and Facilities Research Division, AMS

Problem. Many of our conventional consumer packages and shipping containers (1) are relatively expensive; (2) require a substantial amount of labor to assemble, fill, and close; (3) are comparatively heavy, hence costly to transport and difficult to handle; (4) are unsuitable for storage; (5) do not adequately protect their contents from damage; (6) fail to make an attractive retail display to stimulate impulse buying; and (7) lose potential sales because of poor visibility provided for contents. Furthermore, the marketing of agricultural products has been subjected to rising costs of materials, labor, and transportation and to a revolutionary change in the fresh food distribution system at the retail level--the emergence and takeover by the supermarkets. Supermarkets are dependent on a high level of self service but self service breaks down without a price-marked, unitized product. This has increased the need for improved packages which provide consumers with perishable agricultural products in better condition than those often found in bulk displays. Cheaper, more attractive, and more protective packaging, which cuts transit and handling damage losses, should stem the decline in consumption of many fresh commodities and contribute to increased returns to farmers.

USDA PROGRAM

This is a continuing program of applied research involving marketing specialists, industrial engineers, and agricultural economists to (1) develop new or improved consumer packages, master containers, packing materials, and shipping containers for agricultural products; (2) evaluate them from the standpoint of costs of materials and direct labor to pack, and their ability to reduce product damage and to increase its salability; (3) determine at which point in the marketing system packaging can be done most effectively; (4) improve the efficiency of packaging methods to cut costs; (5) and investigate the needs for and benefits of container standardization and simplification. Current packaging and container research is concentrated for the most part in six commodity areas, each with differing needs: Deciduous fruits, citrus fruits, vegetables, potatoes, poultry, and dairy products. The program is carried on in cooperation with experiment stations in California, Oregon, Washington, New York, South Carolina, Arkansas, Delaware, and Florida; at branch field stations in Orlando, Florida, Fresno, California, and Yakima, Washington; in other main producing areas, and in the principal terminal markets.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Manufacturers and Suppliers. The 1960 Directory of Industrial Research Laboratories in the United States lists 75 firms engaged in packaging research and 37 doing research on various types of containers, such as boxes and bags. More than 30 of our recent cooperators are included in the listings. The directory indicates that their laboratories are staffed by from 20 to almost 400 professional workers each. However, much of their research centers on formulation of basic materials and methods of conversion to end-product components of packages and containers.

Furthermore, most new packages and containers are aimed at penetration of non-agricultural markets. It is estimated that between 100 and 150 researchers of professional status are engaged directly in the development of consumer packages, master containers, bulk shipping containers, and packaging materials for possible use by growers, packers, shippers, and distributors of agricultural products. This work does not duplicate but is correlative with USDA research which evaluates new packages and containers and is primarily concerned with their ability to satisfy the requirements of specific agricultural commodities.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Poultry. Four experimental shipping containers were evaluated and compared with the conventional wirebound crates for delivering fresh-dressed ice-packed poultry to nearby markets. The containers included in the study were three types of moisture-resistant fiberboard boxes for a single delivery, and a returnable wirework basket with a disposable polyethylene liner, developed by researchers. The arrival condition of the birds packed in the experimental containers was good. The trade reaction to the three types of moisture-resistant fiberboard containers and the returnable wirework baskets was favorable. A two-piece moisture-resistant fiberboard box and the returnable wirework baskets completely eliminated entrance of foreign matter and drainage from overhead. The costs, including container, accessory materials, and direct packing labor to deliver 100 pounds of poultry in the three types of moisture-resistant fiberboard containers ranged from \$.91 to \$1.06. Comparative costs for delivering 100 pounds of chickens in the conventional wirebound crates was \$1.02. The most economical way to deliver ice-packed chickens was in the returnable wirework basket. Based on the successful completion of 35 round trips already attained in the tests, the total cost of delivering 100 pounds of chickens amounted to 64 cents; or a savings of 38 cents over the conventional wirebound crates. The "full" useful life has not yet been determined. However, it is estimated that the baskets will survive an additional 35 trips. Eighteen truck shipments were originated in cooperation with five poultry processing plants. Packing and handling studies, and costs of labor, containers, and accessory materials were recorded in each plant.

An evaluation of five different transparent shrink films was made to determine the most suitable for overwrapping cut-up, prepackaged frozen poultry in trays at point of processing. Under commercial conditions in a Georgia packing plant, eviscerated chickens were placed on trays, overwrapped with film, and moved into a freezing room with a temperature 40 degrees below zero. The next day the frozen birds were packed 24 to a master container, loaded into a refrigerated truck and hauled to a commercial warehouse in Philadelphia. The chickens were distributed as needed to supermarkets which were regular customers. Observations in the retail stores indicated that all the films met with favorable acceptance by consumers; no significant consumer preference existed for any one. One polyvinyl chloride film of a lighter gauge than the other four showed significantly more tearing than the others. The acceptance of frozen poultry was better than had been anticipated. Sales of frozen as compared to ice-chilled poultry increased as time went on and the shoppers became familiar with the packaged frozen chickens.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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IV. ECONOMIC RESEARCH

ECONOMICS OF MARKETING
Marketing Economics Division, ERS

Problem: Within most agricultural processing industries rapid and drastic changes in their market organization and practices are occurring. These changes are affecting both farmers and consumers. Research is needed to keep abreast of such changes and to indicate their probable consequences. There have been substantial advances in recent years in increasing efficiency and reducing costs through adoption of new technology in producing, assembling, processing, and distributing farm products. However, for producers and marketing firms to remain competitive additional information is needed on margins, costs, economies of scale and efficiencies possible in the marketing of farm products. A significant aspect of the problem in marketing is that this type of information must be obtained from firms engaged in business -- in contrast with other types of research where the problem can be transferred to a laboratory, experimental plot, or other simulated situation. Consequently, it requires the cooperation of people engaged in making their living and assisting with marketing economic research on the side where their own merchandise, facilities, and opportunity for profit and loss to themselves is involved. Another aspect of the problem is that only large firms can afford this type of research, consequently, public research has been requested for the many smaller firms. Furthermore, there is the need for comparison and analysis where even large firms do not have access to the plants and records of competitors.

Also, marketing research is increasingly directed toward evaluating present and prospective programs pertaining to agriculture such as the Food Stamp Program and Federal grading activities and to the changing structure of market industries. Changes in programs or market structure may influence the bargaining power of farmers. Marketing research also is being directed to the economics of transportation and storage activities of both private firms and government. Increasing attention is being given to the longer-term outlook for various products and markets as an aid in better assessing the prospects for increasing industrial employment under the Rural Area Development Program and in assessing prospective inter-regional shifts in the areas of production and marketing for specific products.

USDA PROGRAM

The Department has a continuing program to determine the reasons for the changes that are taking place in marketing so that ways can be found to increase the efficiency of the marketing system and make it more responsive to changing public needs. Because nearly 60% of the consumer's dollar spent for poultry and eggs goes for marketing activities, this work encompasses a wide range of subject-matter.

It covers all economic aspects of marketing from the time the products leave the farm until they are purchased by ultimate consumers. Much marketing research is functional in nature and could apply to a number of commodities. To the extent the research effort devoted to poultry and eggs can be distinguished, it is shown in terms of professional man-years in parentheses at the end of the following subareas:

A. Market Potentials for New Products and Uses.

This work is directed at the commercial feasibility and market potentials of new or improved poultry and egg products, appraisal of their impact on present markets, and of the economic and technical requirements of end-uses. Such evaluation will provide a sound economic base for decisions on commercial development as well as information to guide further utilization research by physical scientists. (1.5)

B. Merchandising and Promotion.

This is research to evaluate promotional programs to determine: (1) Responsiveness to advertising and promotional activities, and to identify characteristics of products that are responsive saleswise to promotion; (2) relative effectiveness of different promotional techniques or approaches when employed alone or in combination; (3) sales response-promotional investment relationship for selected products; and (4) organizational structure and procedures for optimum control, coordination and effective conduct of program. Another phase of the research program involves analysis of movement and availability data at retail and wholesale levels, and consumer purchase data by family characteristics including regions, rural and urban areas. This research delineates markets and provides producer groups information on movement and market profiles for specific products in planning and executing marketing programs.

Research is conducted to determine the influence on sales and consumer demand of merchandising practices and pricing policies characterizing the marketing of specific commodities at the retail and wholesale levels of distribution. Evaluations are planned so that findings contribute to general principles and standards of performance relating to such factors as methods, type, location and size of displays; type, kind, color and size of package; variety and quality of products; and pricing techniques. Another basic area of research is designed to increase the efficiency of management through improvements in accounting procedures, inventory control, ordering, space allocation, and functional coordination between wholesalers and retailers, and thereby reduce costs associated with these items in the distribution of farm commodities. (1.2)

C. Economics of Product Quality.

This program of basic and applied research on the economics of product quality includes study of the problems of seven different commodity groups. Work on all commodities is carried on at Washington, D. C. An early contribution made by government to improve the economic well-being of farmers was the establishment of standards for farm products. This assured the dependability of quality and strengthened farmers' competitive position. Knowledge of the impact of government grades on market practices and market structure provides a basis for answers to questions of public policy related to government grading programs. (0.6)

D. Marketing Costs, Margins, and Efficiency.

This is a continuing long-term program. In nearly all studies, close cooperation is maintained with industry and trade groups and with individual private firms that provide essential data from their records and make their plant facilities available for observation in the conduct of various marketing tests. Much of the research is problem-solving in nature with a limited amount of research devoted to development of improved research techniques. Although much of the research is conducted by personnel in Washington, D. C., a considerable part of the work is done by USDA professional staff located in the States. (7.3)

E. Market Structure, Practices, and Competition.

This area of work is devoted to analyzing the competitive positions of commodities; producing areas and farms; and the changes within marketing firms in response to shifts in location and technology of production; changes in demand and location of population; changes in transportation, processing, and marketing methods, development of new products; and changes in agricultural programs.

Within the program dealing with poultry and eggs, the study of inter-regional competition is a central feature of regional research projects in the Northeastern, Southern, and Northcentral regions. There are contributing projects involving USDA employees stationed at Durham, New Hampshire, (working in cooperation with the New Hampshire and Massachusetts Agricultural Experiment Stations) and Knoxville, Tennessee, (working in cooperation with the Tennessee Agricultural Experiment Station). Work at the new field office at St. Paul, Minnesota, which will be carried out in cooperation with the Minnesota Agricultural Experiment Station, will contribute to the Northcentral regional project in the area of interregional competition.

Studies of the structure of the commercial hatchery industry of the combinations of the egg-type and broiler-type chicks and turkey poults under one management and of the relationships between the breeding and hatching industry and other production and marketing firms are being

conducted in Washington and in cooperation with various field stations. Work on the extent and nature of vertical integration in the turkey industry is being initiated by Washington personnel following a pilot study supported by Economic Research Service in the field. The organization and development of the Georgia egg industry is being studied in cooperation with the Georgia Agricultural Experiment Station. (4.8)

F. Information, Outlook, and Rural Development.

This continuing program is designed to assist the Department in improving the usefulness of its output of marketing information through studies (1) to evaluate the uses made by both private and public users of information; (2) to determine the nature of the primary needs of these users for information; (3) to develop improved means of collecting data, making estimates, and reporting essential information; and (4) to evaluate impacts that information services have on decision-making by farmers, marketing firms, and public and semi-public agencies. Research is in progress in cooperation with the Dairy and Poultry Market News Service to develop and test weekly reports on the movement of shell eggs into retail channels in 18 major metropolitan areas that together consume more than half of the eggs produced in the United States. Successful reports are now operating in 9 cities and work is underway in 9 others. The individual city reports are designed so that they can be combined into a national report giving a good indication of current movements of eggs out of marketing channels into the hand of final users. Plans are being made to develop and test similar reports for broilers and turkeys. The professional man-years of effort specifically for poultry and eggs is not available.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

A brief but overall treatment of poultry research by States and industry is included in the "Introduction," beginning on page v. To the extent information was available the work by States and industry is reported under the following subareas with professional man-years shown in parentheses at the end of each section:

A. Market Potentials for New Products and Uses.

In 1961 New York (Cornell) was engaged in developing new products and uses from eggs and fowl as a part of an effort to expand markets for these products. (2.0)

B. Merchandising and Promotion.

Studies in the Northcentral region include merchandising aspects of egg breaking and drying, developing market outlets for inedible poultry byproducts, and influences of trade practices on egg quality. Two studies in the Northeast emphasize the effectiveness of different merchandising practices on sales of meat and eggs at the retail store level. In the South the current studies are part of a larger regional project in which the USDA is cooperating. By division of labor, two States handle for the region phases of the broader problem dealing with consumer preferences and motivations in buying poultry products as related to production characteristics and merchandising methods, consumer preference versus acceptance of selected characteristics in table eggs and egg packages, and market potential for frozen broilers. The Western studies analyze poultry product availability in retail stores, the role of egg carton labeling in retail marketing, and measures of effectiveness of selected techniques for increasing demand for broilers. (4.3)

C. Economics of Transportation and Storage.

One Northeastern station has been assigned major responsibility for regional poultry and egg marketing project NEM-21, Adjustments Needed in Marketing Northeastern Poultry Products. This study relates to the impacts of feed and poultry product transportation rates and costs on the relative competitive situation of the poultry industry of the region. (0.3)

D. Economics of Product Quality.

Current studies directed at specific problems of egg quality include analysis of selected market outlets for locally produced eggs, an evaluation of the quality of eggs offered for sale and factors affecting quality and price in selected stores, and contrasts in quality of domestic versus shipped-in eggs. (1.6)

E. Marketing Costs, Margins, and Efficiency.

A number of projects are underway in this commodity area. Northcentral studies include the relation of volume of poultry products sold to marketing costs, means of improving the efficiency, and developing market methods, techniques, practices, and facilities for poultry and eggs, and costs of operating egg cartoning plants. Two studies in the Northeast are contributing to the regional project NEM-21, Adjustments Needed in Marketing Northeastern Poultry Products, and deal with problems of adjustment in the broiler industry related to area competition and market demand and individual firm efficiency and industry adjustments to improve marketing. Other studies include efficient processing and utilization of chicken meat, and effects of market innovations on costs and returns for poultry.

Five projects in the South are contributions to a regional project in cooperation with USDA, SM-15, Competitive Position of the South in Marketing Eggs and Broilers. Four of these studies relate to egg marketing and include factors affecting costs of assembling, grading, and packaging table eggs under different marketing practices and methods. One study investigates the effect of market organization and structure and scale of operation on broiler marketing costs and efficiency. The Florida station is making an economic study of factors affecting the chick hatchery industry. The Texas station is studying costs and efficiency in marketing table eggs. (7.6)

F. Market Structure, Practices, and Competition.

Because of rapidly changing conditions and diversity among areas, the market structure and practices for poultry and eggs is being studied in a number of locations at the present time. The Northcentral region has recently initiated a new regional study NCM-31, The Effects of Coordinated Egg Production - Marketing Programs and New Marketing Technology upon Market Channels and Institutions. Division of study among the States will take place for regional attack on specific problems and evaluations of alternatives and potentials. Alaska is investigating egg marketing problems of that area. Indiana is making an intensive study of marketing practices for poultry products, with emphasis on that segment of the marketing channel from the processor or handler to the retailer.

Eight States in the Northeast have nine projects which are contributions to regional project NEM-21, Adjustments Needed in Marketing Northeastern Poultry Products, that includes both egg and meat segments. Four States with five projects are studying various phases of egg procurement practices of retail marketing firms, alternative systems of servicing the various egg markets at different stages in the marketing channel, and the competitive position of the region in servicing such markets. Four States have projects concerned primarily with the competitive position of the market for broilers, including condemnation losses, dressing percentages, pricing arrangements, and development of new marketing technology.

Two States have three projects which are a part of regional study SM-15, An Economic Appraisal of the Competitive Position of the South in Marketing Eggs and Broilers. One study examines the effect of alternative marketing systems on egg quality and marketing costs at the retail store level. Two studies explore decision-making and coordination in management in vertically integrated broiler servicing and processing firms, and factors affecting optimum market age and average weight of commercial broilers.

The Washington station is evaluating developments in marketing techniques and practices for poultry processors and retailers.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE RESEARCH

A. Market Potentials for New Products and Uses.Market Potentials for Improved Egg Products in Remanufacturing Uses.

Most of the work on this study to determine the market expansion possibilities for egg products of improved quality in remanufacturing uses has been completed. The data collected have been analyzed and the manuscript of the report of the findings is being prepared. Based on the findings from this study it would appear that the use of dried egg products and egg-containing prepared dry mixes will increase substantially in the years immediately ahead. Increases in the use of dried eggs will be largely at the expense of frozen eggs. The convenience aspect of dried eggs and pre-mixes appeals strongly to industrial users. Resistance to the use of dried eggs and pre-mixes is fast disappearing, and apparently, is no longer a strong deterrent to expanded utilization, with the possible exception of the small retail baker.

B. Economics of Product Quality.

Effects of Egg Quality on Marketing Costs and Returns. This study will provide information on the effects of various production and handling practices on producer returns and of variations in egg quality on marketing costs. No findings are available. (ME 2-49)

C. Marketing Costs, Margins, and Efficiency.

Among the comparatively new active projects are studies on the following problems: Three regional studies in cooperation with State experiment stations concerning (a) appraisal of the competitive position of the South in marketing eggs and broilers, (b) coordinated egg production-marketing programs in the Northcentral States, and (c) economic and institutional adjustments needed for efficient marketing of poultry products in the Northeast.

Results of an incomplete study of commercial hatchery costs and operating practices indicate that substantial cost reductions are possible particularly from economies of large scale and economies of operating near capacity levels for longer seasons. Most of the economies of size in broiler-chick hatcheries are achieved with an incubator capacity of 500,000 eggs. In a sample of North Carolina hatcheries studied, average costs per chick range from only 1.6 cents to 6.0 cents. However, operating cost estimates for model hatcheries based on studies in New England and North Carolina range from 2 cents per chick for a hatchery producing about 1.5 million chicks annually to 1 cent per chick at 15 million chicks per year. The number of hatcheries in the U. S. has declined more than 50 percent in the past 20 years, and the average size of firm has increased. Hatcheries are now operating with a higher rate of use of capacity, for longer seasons, with less hatching

on a custom basis, with greater reliance on contract flocks for supplies of hatching eggs and with more integration with other elements of the poultry industry. About 40 percent of a national sample of 643 hatcheries are franchised by breeders to hatch and sell designated strains of chicks or poults within particular areas. Four reports have been published on this study and other manuscripts are being written.

In a study of the economic requirements for development of a commercial egg industry in the South, models of 7 different egg candling and distributing plants have been developed. For consumer graded and cartoned eggs, total costs of operation range from \$1.77 to \$1.92 per case. Costs decrease as size of plant increases from 7 cases an hour to 120 cases an hour. Increasing productivity of labor and, hence, decreasing labor costs per case explain nearly two-thirds of the variation in labor costs. Labor costs are about a third of total costs and packaging materials about 40 percent. Vertical integration and contract production programs lead to better coordination of production and marketing, with resulting possible savings, by reducing the seasonality of production and plant operations. Additional, more comprehensive, reports on this research are in preparation.

An appraisal of ways to increase the efficiency of egg assembly in the West Northcentral region reveals that savings of 15 to 45 percent may be accomplished through realignment of routes, the use of set-in stations, the recognition of paying price differentials based on volume picked up and more attention by management to procurement and assembling programs. At the time of the study, total assembly costs per case for 20 routes averaged 38.6 cents. The lowest total cost per case was 20.0 cents, the highest 53.1 cents. Labor costs per case averaged 20.0 cents with a low of 10.2 cents and a high of 30.9 cents. Truck costs averaged 18.6 cents per case with a low of 5.7 cents and a high of 36.2 cents. Total costs per mile including truck and driver averaged 22.5 cents with a low of 17.3 cents and a high of 37.1 cents. Of the total volume of eggs handled by 7 Midwestern assemblers, 46 percent came from producers with 4 cases or more of eggs per pickup. Average assembly costs per dozen ranged from 3.5 cents for less than 1 case picked up per farm down to about 0.25 cent per dozen for 4 or more cases. Paying prices reflecting such differences in assembly costs might encourage more farmers to produce larger volumes of eggs per farm and help plants to reduce egg marketing costs. A manuscript is in process of clearance.

A study designed to appraise the possibilities for reducing costs of assembling and processing turkeys, both from the standpoints of operating efficiency and industry structure is nearing completion. Data from 25 plants show that economies of scale exist in turkey processing, and that costs and returns are also affected by seasonality of operations, market classes of turkeys handled, supply sources and market outlets. Costs of processing turkeys in frozen, ready-to-cook form range from 6.6 cents per pound in small plants to 5.4 cents per

pound in larger plants. Operating costs per pound are lower for good quality heavy young hens and toms than for breeders and fryer-roaster turkeys. Costs can be reduced by increasing plant size toward the optimum level, better utilization of capacity, substitution of equipment for labor, and better organization of the working force and supervisory activities. Efficiency in assembly of turkeys is affected by truck and crew size, length of haul, size of birds, catching and loading arrangements, and weather conditions. Further work on the coordination of production and marketing functions in the 10 leading turkey States is in progress. Analyses of the economic consequences of alternative structural arrangements have been initiated. Reports on costs and economies of scale in processing turkeys and on assembly systems are in preparation.

In a study designed to develop least-cost systems of performing production, marketing, and supply functions in the broiler industry in New England, reports have been issued on the relative profitability of alternative production, processing, and selling programs of processors under average market price levels, and on the possibilities for reducing live assembly costs. Under the price relationships prevailing in New England during recent years, direct contracting between the plant and the grower was the most profitable method of procurement. Market prices of live broilers and costs of growing varied seasonally and inversely. It pays plant operators to operate at capacity rather than to vary volume with seasonality of demand and prices. If the additional costs can be recovered, a partial shift toward frozen and further-processed products would even out prices and facilitate more orderly marketing. Size of firm and density of the supply areas are major factors affecting assembly costs. If poultry is available at the rate of 100 pounds per mile of truck travel, unit costs in assembly decline from 0.90 cent per pound for a firm handling 1 million pounds per year to 0.47 cent per pound at 50 million pounds. Increasing the pounds per mile of truck travel to 1,000 lowers unit costs to 0.60 cents per pound for 1 million pounds and 0.35 cent per pound at 50 million pounds. Costs of assembling live poultry in New England can be reduced from \$4.6 million to \$2.9 million by capacity operation in fewer firms with exclusive supply areas. Synthetic models have been used to adapt the results of live assembly cost studies to the development of planned systems for integrated organizations. The institutional characteristics of the New England hatchery were summarized, and a manuscript has been prepared on costs of hatchery operation and chick distribution. Seven model feed mills are being developed synthetically to study economies of scale in feed milling, and studies of the costs of distributing feed are underway. Work in the feed milling and distributing phases will be completed. An analysis of the costs of assembling hatching eggs will be made. Least-cost systems of distributing processed poultry to retail organizations will be evaluated.

Evaluation of total systems, including egg supply flocks, broiler production units, hatcheries, feed mills, and processing plants, will be completed. These will aggregate the costs for the individual function, and establish the combinations which yield lowest costs under specified conditions.

A guide to uniform cost and financial accounting for poultry processors has been developed and published. This new system of cost accounting can be used by processors to evaluate the efficiency of their own operations and, thereby, to make needed improvements in operating methods. A voluntary system of cost comparison among poultry processing plants all developing cost information under this system of accounting could be especially helpful to the participating plants in pointing to the causes and possible remedies of weaknesses in plant operations.

Studies of marketing margins on poultry and eggs reveal wide differences among 10 major cities. While farm-retail price spreads on Grade A large eggs averaged 24 cents a dozen in 1955-60, the Los Angeles average was 15.4 cents and the New York City average spread was 30.1 cents. Differences in the type and efficiency of distribution systems and practices, distances of major producing areas from the cities, and procurement and merchandising policies of major retailers are major factors underlying these large differences in marketing margins. Farm-retail price spreads on frying chickens averaged 20 cents a pound and the 1955-60 averages ranged from 15.6 cents a pound in St. Louis to 37.8 cents in San Francisco. On medium turkeys, the average 1955-60 margin was 20 cents and the city averages ranged from 15.1 cents in Los Angeles to 27.8 cents in Washington, D. C. Nationally, margins taken by retail stores averaged 40 percent of the total farm-retail price spread for Grade A large eggs, 42 percent for turkeys, and 53 cents for frying chickens.

In New York City, prices and price spreads for Grade A large eggs in cartons average 3.9 cents and 2.3 cents a dozen, respectively, higher in small independent food stores than in independent or chain supermarkets. The small stores also paid more, about 1.6 cents a dozen. Egg prices at all levels in the city move in a close, but by no means, exact relation to Urner-Barry spot quotations for nearby large white eggs.

D. Market Structure, Practices, and Competition.

Research designed to evaluate the possible economic bases for marketing orders and agreements and to determine if these would be preferable to other marketing arrangements provided valuable background for administrative use in connection with proposed legislation and proposed programs under the Agricultural Marketing Agreements Act of 1937, as amended. Analysis of the National Turkey Federation proposal pointed out some of the defects, particularly from the standpoint of

the public interest. A review of literature and theory provided the basis for several papers discussing the possible use of marketing orders and other techniques to improve farmer's bargaining power on turkeys, broilers and eggs. Preliminary estimates were made of short-run effects on farm and consumer prices if marketing orders were used.

Study of the present egg pricing system and alternatives to it indicates that during periods of low egg prices, the base price quotation system is heavily criticized by producers and others in the egg trade even though it is not the primary cause of low prices. Thus, interest in egg pricing research rises and falls cyclically, although the problem is basic and needs study in depth over time. Most actual prices are determined by discounts below and premiums above base prices, particularly the New York quotation. If the present system were to be retained, some expansion in Exchange trading and further changes in the condition of trading would be desirable. If the volume of trading is too thin, quotations may not be representative of the bulk of the eggs moving through trade channels. Despite this drawback, many of the alternatives to the present pricing system that have been proposed, completely beg the question of how to discover new prices or new values for the product. The most likely alternative seems to be the establishment of pricing committees.

Research on the egg procurement programs of large-volume retailers and their suppliers shows that virtually all of the large-volume retailers view themselves as quality leaders offering eggs to consumers at competitive prices. However, the suppliers had a different image of some of the retailers.

Predominate systems of egg procurement used by large-volume retailers are: (a) candling and cartoning of loose eggs by retail warehouses in or near metropolitan areas; (b) receiving cartoned eggs at retail warehouses in truckload lots; (c) retailer-owned subsidiary candling and cartoning facilities at country point or in metropolitan distribution area; (d) country assemblers or wholesale receivers supplying eggs to individual stores; (e) single farms supplying individual stores.

Prices paid for eggs by large-volume retailers are determined mainly by applying premiums to various base price quotations issued in metropolitan areas such as New York City, Boston, and Chicago. The New York City base price quotations were used extensively in many cities along the Eastern Seaboard and extending into the Midwestern States. Within individual metropolitan areas a fairly high degree of consistency was found in the premium structure over the base, and for markets using the same base, the difference in premium structure reflected mainly transportation differentials. However, the use of different base price quotations in the various metropolitan areas resulted in varying returns to producers.

E. Information, Outlook, and Rural Development.

Studies revealed ways to improve and develop market news reports on the volume of eggs moving into retail channels in large metropolitan areas. In February 1960, improved weekly reports were being issued to the public in Seattle, San Francisco, Los Angeles and Chicago, and a new report for the Portland-Vancouver metropolitan area was begun. These reports contain information on the weekly volume of eggs for each metropolitan area and comparisons with the previous week and the same week a year ago. The information for each area can be aggregated to obtain movements for all reporting areas.

Surveys of egg handling firms in 13 additional metropolitan areas have been completed the last two years. Weekly reports were released for the Philadelphia and Baltimore metropolitan area beginning in March 1961; for the New York and Boston areas in June 1961; for Pittsburgh in September 1961; Detroit in October 1961; Kansas City in January 1962; St. Louis and Atlanta in March 1962; and Birmingham and New Orleans in June 1962. Surveys designed to establish a universe of firms and planned reporting procedures have been completed for Minneapolis-St. Paul and Miami.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Marketing Costs, Margins, and Efficiency

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- Rogers, G. B. January 1962. How would marketing orders or quotas work on eggs? Talk at meeting of Minnesota Poultry Hatchery Assn. and Minnesota Eggs Producers Assn., Minneapolis, Minnesota.

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Information, Outlook, and Rural Development

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IMPROVING MARKETING OPERATIONS THROUGH
RESEARCH WITH FARMER COOPERATIVES
Marketing Division, FCS

Problem. Farmers, in marketing their production, face a revolutionary change in terms of market organization and marketing practices. The ever increasing and important supermarkets require large quantities, good quality, and frequent delivery which the small farmer, working alone, or a cooperative, or local firm of limited size cannot supply. Cooperatives must find ways to consolidate volume, either through internal growth, merger, acquisition or federation to help reduce marketing costs by increasing efficiency through improved operations, better organizations, and more mechanization.

Farmer cooperatives are an important part of the distribution system and represent a major potential for meeting the farmers' marketing problems in the modern distribution system. They are organized and operated to increase farmers' net income. Through cooperatives, farmers seek to increase their bargaining power; obtain needed services at cost; improve the quality of farm products; and obtain a larger share of the consumer's dollar. Cooperatives face many problems in achieving these objectives. Research is needed which will assist marketing cooperatives, as well as other marketing agencies, solve their problems by making available essential factual information and developing practical and useful operating plans and procedures.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operations and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The number of Federal professional man-years involved in this work totals 24.8 of which 3.6 are devoted to cooperative marketing of poultry and eggs.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State experiment stations are devoting 6 man-years to research on cooperative marketing. The work includes 0.8 on poultry and eggs in Utah to determine to what extent poultrymen market eggs through cooperatives and what the trend has been in recent years. It is estimated that annual expenditures for research by cooperatives is equivalent to 11 man-years. This includes work on poultry and egg marketing, livestock marketing including analysis of facility needs. Also included is research by farm supply cooperatives such as possibilities for integrated pork and beef programs, cow pools, consumer acceptance of frozen apple juice and prebaked beans, and feasibility of cooperative marketing of sugar beets.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Costs and efficiency. The objective of this research is to increase the efficiency in egg marketing at the first receiver level. This broad objective was to be achieved by analyzing costs and labor requirements of individual operations in egg handling; by determining and measuring the factors affecting costs and labor output; and by applying findings to actual operating conditions.

The findings show wide variations in costs among the firms studied -- for instance, as much as 60 cents per case candling labor cost and a high egg receiving labor cost six times that of the lowest. The unit direct labor costs varied chiefly because of: (1) Differences in wage rates and other labor costs, (2) differences in unit output per man-hour, and (3) differences in cost of materials and equipment for the candling and cartoning operation. The most important means of lowering egg handling costs are by: (1) Increasing the volume of eggs handled, (2) greater use of laborsaving equipment, (3) more efficient use of labor, (4) better plant layout and equipment layout, (5) improving egg quality at farm level, and (6) integrating services.

Improving fowl marketing of cooperative and other handlers. The objective of this research is to examine the present fowl marketing situation, and evaluate new and potential ways to increase producer returns from fowl.

The findings to date indicate that: (1) Fowl prices appear unjustifiably low in relation to the food value of fowl; (2) the marketing structure and organization are not generally satisfactory competitively from the producer standpoint; (3) new uses and marketing and merchandising methods are needed; (4) there is need for more and improved market channels and outlets and for more competition at the processing and distribution levels, and (5) more research is needed on the development of new products from fowl of the further processed convenience type.

Improving operating methods. Considerable research and service work has been done during the past two years with cooperatives in various States to assist them in their efforts to federate, unify, or consolidate. In California three cooperatives serving egg and poultry producers have recently merged as a follow-up of two studies made in the State regarding the advisability and feasibility of California egg and poultry cooperatives combining. The State Experiment Station conducted related work with the cooperatives.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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ECONOMIC AND STATISTICAL ANALYSIS
Economics and Statistical Analysis Division, ERS

Problem. Adequate and accurate information is needed on supplies, production and consumption of farm products, and the effects these and other factors have on the prices of agricultural commodities. Such information is needed in planning operations for the producers, processors and distributors and also benefits the consumer in selecting his purchases. Similarly, accurate quantitative knowledge of the inter-relationships among prices, production and consumption of farm products are needed by Congress and the administrators of farm programs to effectively evaluate current and future price support and production control programs.

Due to the instability of the prices he receives, the farmer stands in special need of accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The farmer needs to be provided with economic facts and interpretations comparable to those available to business and industry, through a continuous flow of current outlook intelligence and the development of longer range projections of the economic prospects for the principal agricultural commodities.

USDA PROGRAM

This includes the regular publication of 12 commodity outlook reports, the holding of the Annual Outlook Conference in Washington in mid-November, participation of outlook specialists at regional or State outlook meetings or at meetings of farm organizations and agricultural industry groups, preparation and publication of special articles bearing on both the short-run and long-run outlook for farm commodities, issuance of comprehensive statistical bulletins containing the principal economic series pertaining to the various commodities, long-range projections of the demand for the major agricultural commodities, and continuing analysis of the impact of various alternative farm program proposals as they affect output and prices of these commodities. The total commodity situation and outlook program currently involves 24 professional man-years.

The work in poultry involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation for poultry and eggs. Appraisals are published regularly in the Poultry and Egg Situation, the Demand and Price Situation, and the National Food Situation. A comprehensive analysis of the poultry and egg situation is presented at the Annual Outlook Conference. Outlook appraisals are also frequently presented at regional or State outlook meetings, at meetings

of farm organizations and to various agricultural industry groups. Special analyses are prepared from time to time on the probable effect of proposed programs on the price, supply and consumption of poultry and poultry products. Basic statistical series are developed, maintained, improved and published for general use in statistical and economic analysis. As a part of this program, a comprehensive bulletin entitled, Egg and Poultry Statistics, was released in March 1962. Returns from producing eggs, broilers, and turkeys are subject to wide fluctuations which made an effective outlook service for producers of these commodities imperative.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

Research of State experiment stations in this area is not reported separately but is included with research reported under related areas.

A substantial number of private organizations - including manufacturers of food and fiber products, private commodity analysts, banks, and investment houses - are engaged in commodity outlook work similar to that carried on by USDA. This work, however, frequently related to shorter time periods than those covered by the Department's outlook appraisals; is predominately for private use; and not available to the public. Furthermore, much of the work of the private organizations is heavily dependent on the regular USDA.

A few private colleges and organizations are engaged in price research, and may give attention to agricultural products from time to time. It is estimated that work on agricultural products may involve 5 to 10 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

The commodity situation and analysis indicated that a huge expansion in broiler and turkey production in 1961 resulted in greatly depressed prices and a record large carryover of frozen turkeys into 1962. Broiler prices dropped to record low levels and turkey prices were the lowest point since the early 1940s. In addition, egg prices in the fall of 1962 failed to show the usual seasonal advance and remained much below the year earlier through early 1962. As a result of these developments, adjustments making for a reduced output of all of these commodities began in late 1961 and the first half of 1962. These are leading to about a 15 percent cut in turkeys raised in 1962, somewhat smaller broiler production in 1962 through October, and egg production back down to year earlier levels by the last quarter of 1962. However, broiler prices much above the 1961 level in June through September have triggered a huge expansion in chick output which will boost broiler marketings in late 1962 much above the year before and greatly depress prices from present levels.

In 1961 and early 1962, attention was focused on the factors that had led to the overproduction and low prices of 1961. In addition, many of the important long-term trends bringing about changes in the demand and supply of poultry and eggs were analyzed in considerable detail. This emphasis was partly to provide necessary background material for the advisory committees and others who were considering what steps might be taken to stabilize poultry and egg prices.

In the March issue of the Poultry and Egg Situation, a comprehensive analysis of the probable impact of the new Common Market trade regulations on the rapidly growing U. S. poultry exports was presented. U. S. poultry exports increased almost 5-fold between 1958 and 1961. About three-fourths of the increase has been to Western Europe, mainly to West Germany. Higher hurdles will confront U. S. poultry exports to the European Economic Community during the current fiscal year.

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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CONSUMER PREFERENCE AND QUALITY DISCRIMINATION--
HOUSEHOLD AND INDUSTRIAL
Statistical Reporting Service

Problem. With the increasing complexity of marketing channels and methods, it has become almost impossible for the consumer to express to producers either his pleasure or displeasure with available merchandise. In order to market agricultural products more efficiently, we need to understand existing household, institutional, and industrial markets and the reasons behind consumers' decisions to purchase or not to purchase. Information is needed on preferences, levels of information or misinformation, and satisfactions or dislikes of both present and potential consumers. We also need to know consumer attitudes toward the old and new product forms of agricultural commodities and their competitors, and probable trends in the consumption of farm products. We need to know the relationship between agricultural and nonagricultural products and the relationship of one agricultural commodity to another in consumers' patterns of use. Producer and industry groups and marketing agencies consider this information essential in planning programs to maintain and expand markets for agricultural commodities which, in turn, increase returns to growers.

USDA PROGRAM

The Special Surveys Branch of the Standards and Research Division conducts applied research on representative samples of industrial, institutional, or household consumers and potential consumers, in local, regional, or national marketing areas. Such research may be conducted to determine: attitudes, preferences, buying practices, and use habits with respect to various agricultural commodities and their specific attributes; the role of competitive products, and acceptance of new or improved products.

The Special Surveys Branch also conducts laboratory and field experiments in sensory discrimination of different qualities of a product. These studies ordinarily relate discrimination to preferences and attitudes as they influence purchases in order to assess the standards of quality, packaging, etc., which are needed to satisfy consumer demands.

In addition to surveys of consumer preferences and discrimination, the Special Surveys Branch also provides consultants and conducts special studies, upon request, for other agencies within the Department of Agriculture or within the Federal Government, when survey methods can be usefully applied to the evaluation of programs, services, or regulatory procedures of interest to the requesting agencies.

The work of the Branch is carried out in cooperation with other Federal governmental agencies, divisions within the Department of Agriculture, State Experiment Stations, Departments of Agriculture, and land grant colleges, agricultural producer, processor, and distributor groups. Closely supervised contracts with private research firms are used for nationwide surveys; studies in selected areas are usually conducted by the Washington staff, with the assistance of locally recruited personnel.

The Branch maintains all of its research scientists, who are trained in social psychology and other social sciences, in Washington, D.C., which is headquarters for all of the survey work whether it is conducted under contract or directly by the Branch.

The Federal scientific effort devoted to research in this area during the past year totaled 7.0 professional man-years under regular program funds; of this total, 6.8 professional man-years were devoted to consumer preference research and .2 professional man-years were devoted to quality discrimination research. An additional 2.2 professional man-years were devoted to research conducted under transfer of funds arrangements.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Agricultural Experiment Stations. The Stations do not report any of their work under this heading. However, they do have a considerable program in the area of consumer buying and use practices and motivation and decision making. This includes some research in preference and quality discrimination. There is a reference to parts of the stations' program in other division reports.

Industry and Other Organizations conduct research in this area, but the research done by individual firms and organizations is almost without exception for their exclusive internal use. There are very few instances in which the findings are made public or made available for government reference. In addition to the research actually initiated and paid for directly by industry, a substantial amount is undertaken in their behalf as part of the service provided by their advertising agencies.

Producer Groups: A number of food producer groups conduct consumer preference work with their own staff and, in addition, contract for research with private marketing firms. To a large extent, this research is limited to food classes such as poultry, dairy products, citrus and deciduous fruits (rather than being directed to individual branded products). This research ranges from a small to national coverage. It includes taste testing for quality differentiation, new product acceptance, and attitudes toward existing products. The producers of agricultural fibers have a small but active research program on quality evaluation and consumer preferences, both household and

industrial, for cotton and for wool. Estimated annual expenditures by these groups are equivalent to approximately 10 professional man-years.

Food Processors: In the livestock industry most of the larger packers have research programs for evaluating the effect of product change and acceptance of new meat products. A sizable number of other food processors have extremely large programs of consumer research. They are engaged in work on new food forms and convenience foods such as cake mixes, canned and frozen fruits and vegetables, deciduous fruits, citrus fruits, soups, dairy products, and alcoholic beverages. Manufacturers of cooking oils and shortenings support sizable consumer research programs with their own staff and also under contract. Manufacturers of dehydrated foods, such as potatoes, are constantly engaged in consumer research on their own and on competitors' products. Estimated annual expenditures are equivalent to approximately 400 man-years.

Processors of Nonfood Products: Large programs are supported by all of the major chemical manufacturers, directed to consumer preference and acceptance of synthetic fibers and blends. The three largest textile mills which represent a major proportion of the fabrics manufactured in the United States support research of this type. All of the large manufacturers of cigarettes do research to find out consumer taste preferences for their product; what blends, filters and packages are most likely to succeed in catching and holding a market. Estimated annual expenditures are equivalent to approximately 250 man-years.

Miscellaneous Groups: There is a smaller but constant amount of research undertaken by magazines and publishing houses for their principal advertisers. A number of the largest retail stores in our major cities study the consumers' reactions to their merchandise and service by conducting interview studies with customers and noncustomers. One of the largest food retailing chains has an active program in quality research which involves taste testing as well as consumer preference. Estimated annual expenditures for research related to agricultural commodities and nonagricultural products in competition with them are equivalent to approximately 20 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

Poultry. Available information on consumer use of and attitudes toward poultry on a nationwide basis is seriously out of date. Since the last national study on this subject, conducted by the Department of Agriculture in 1956, the production of broilers has greatly increased while prices to producers have decreased. Planning was therefore recently begun on a proposed new survey to be conducted under contract to provide poultry producers current information on consumer preferences, usage, and buying practices.

Family food habits. A study of the effect of differences in national background, education, and occupational status of families on their food habits, done in cooperation with the Pennsylvania State University, was completed and a report has been issued by the University. This study was undertaken to ascertain the effect of ethnic and social characteristics of the family on the relative use of meats, dairy products, and certain fruits and vegetables. National background was found to determine to some extent the kinds and amounts of meats used, although this influence appeared to decline among younger families. Families of American background were more likely to include fruits and fruit juices in their menus than were families of foreign background. Increased education and occupational status resulted in the increased use of fruits, fruit juices, nonleafy green vegetables, and cheese and ice cream, but not in the increased use of whole milk or meats and poultry. (MD 1-23)

Food stamp plan. The Special Surveys Branch participated in an evaluation of the pilot food stamp program at the request of the Food Distribution Division, AMS, which financed the research. Surveys were conducted in two of the eight pilot areas to determine attitudes about, and reactions to, the food stamp program. Groups interviewed were a cross section of low-income families who were, and also those who were not, participating in the program, moderate and higher-income families in the community, food retailers, and welfare workers. Results indicate general satisfaction with the program on the part of all groups. Retail grocers reported their sales increased. Participating families reported an increase in the amount and quality of the food that they consumed, especially in such products as meat, poultry, milk, eggs, and fresh fruits and vegetables. Welfare workers in the study areas were, in the main, satisfied that the program was doing a better job than existing or prior programs in improving the diet of low-income and needy families. Finally, the results indicated that families of moderate and higher incomes, although not themselves eligible for the program, had received the program with the recognition that low-income families should be enabled to obtain more and better food, and generally approved of the food coupon approach.

Preliminary results of these attitude surveys were included in a report on the food stamp plan which was issued by Agricultural Marketing Service early in 1962. A final report to Agricultural Marketing Service is in preparation. (MD 1-48).

PUBLICATION REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Food Distribution Division, AMS, USDA. 1962. The food stamp program: An initial evaluation of the program. Bulletin AMS-472 (MD 1-48).

V. NUTRITION AND CONSUMER-USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help carry out the Department's responsibility to advise on the quantity and variety of foods that will assure maximum benefit and satisfaction to consumers, continuous research is essential on the nutritional requirements of persons of all age groups, and on the nutrient and other inherent values of foods and how to conserve or enhance these values in household preparation and processing. Periodic examinations of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective nutrition education. Such information provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and use.

USDA PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition education programs.

The research is carried out by two divisions of the Agricultural Research Service--the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done in Washington, D. C., and at Beltsville, Maryland; some is done under cooperative or contract arrangements with State experiment stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 61.1 man-years. It is estimated that approximately 3.8 is concerned with studies related to poultry.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and micro-organisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research is described on a nutrient basis in the report for the Food and Nutrition Advisory Committee. The total Federal effort is 29.5 professional man-years.

RELATED PROGRAMS OF STATE EXPERIMENT STATIONS AND INDUSTRY

State Experiment Station research in 1961 included 22.4 professional man-years devoted to studies of the inherent properties of foods and of their household use; 17.6 to analyses of a variety of foods for vitamins, various lipid and protein components, and minerals; and 2.7 to studies of food consumption and dietary levels of households and of food management practices. Although the State work has not been reported on a commodity basis, some of the above research is applicable to this report.

Industry and other organizations such as universities and professional organizations are estimated to devote about 36 man-years to research on the preparation of materials for nutrition education, surveys of diets of individuals, and studies of functional properties and stability of food and of their specific nutrient contents. Limited work is done on the amount and structure of nutrients in foods and on compiling food composition data. Again, some of this work is applicable to this report.

REPORT OF PROGRESS OF USDA AND COOPERATIVE PROGRAMS

A. Nutritive Values of Foods

1. Tables of Food Composition. Data review has been completed for a revision of Agriculture Handbook No. 8, "Composition of Foods... Raw, Processed, Prepared." This edition will have nearly 2,500 food items as compared with 751 items of the preceding edition, and upwards of 45,000 separate compositional values. For many foods, data will be provided for different forms--raw, cooked, canned, frozen, milled, dried, instant, dietetic, etc. The new publication will have, in addition to other constituents, data for protein, fat, carbohydrate, five vitamins (vitamin A, niacin, riboflavin, thiamine, ascorbic acid), six minerals (calcium, phosphorus, iron, sodium, potassium, magnesium). Explanatory notes for foods and nutrients will be added for users of the tables. Information on cholesterol and fatty acids will also be included.

The list of poultry items will be considerably expanded for the revised edition of Handbook No. 8. More kinds of poultry and more detail under each kind, especially for chickens, will be included. The data for chickens will be subdivided by class (fryers, roasters, etc.), and by raw and cooked. The new table will include about 60 items. Turkey items will be subdivided by age and fatness--birds, medium-fat, and fat mature birds--and insofar as possible will include raw and cooked forms. Because of the limited information available, the number of items will be about 30. Duck, goose, guinea, and pigeon will be included but with less data.

For eggs, 18 items will be listed. These will include raw, cooked, and dried chicken eggs as well as raw duck, goose, and turkey eggs. Some baby foods and soups containing appreciable proportions of poultry and eggs will be included.

2. Vitamin Analyses. Values more representative of the vitamin B₆ content of foods now may be obtained by use of a method recently developed at Beltsville, Maryland. Separation by column chromatography of the three forms of vitamin B₆ naturally occurring in foods permit each form to be assayed individually. Values derived from these data for total vitamin B₆ approximate closely values obtained from rat bioassay.

Research is in progress to combine a number of steps in the determination of various B-vitamins in order to facilitate their simultaneous analyses, permit complete characterization of the B-vitamins in foods and to determine their overall distribution in the food supply.

Data were obtained under contract research at Lafayette, Indiana, on the content of thiamine, riboflavin and niacin in meat and skin from raw and cooked parts of 48 ten-week old broiler-fryer class chickens separated into serving pieces. The vitamin A content in raw and cooked gizzard, liver and skin were also obtained. All birds were of the same breed, sex, and age, and received the same ration. The results will be included in the revision of Agriculture Handbook No. 8.

3. Mineral Analyses. The content of 10 mineral elements were determined in brain, heart, kidney, liver, pancreas(sweetbreads), and tongue of beef, and some in lamb, pork, chicken and veal. The data showed the iron content of the livers of swine and chicken was more than twice that of the livers from ruminants. By far the highest iron values were found in pork liver. Copper content of

lamb liver was about three times that of beef or veal and 10 times that of pork or chicken liver. Sodium of pork pancreas was lowest among the organs studied. The data have been published and the studies terminated.

Foods were assayed for mineral element content using the emission of spectrograph for determinations of aluminum, boron, calcium, copper, iron, magnesium, manganese and phosphorus, and the flame photometer for the determinations of sodium and potassium.

4. Proximate Composition. Determination of the proximate composition of foods, i.e., moisture, fat, kjeldahl nitrogen and ash, were carried out in conjunction with studies for other nutrients in foods such as the vitamins, mineral elements, fatty acids and carbohydrates. Such an arrangement added to the information on composition of foods in the various commodity groups and also permitted the calculation of nutrients on a fat-free moisture-free basis or on a nitrogen or protein basis where relationships among nutrients were concerned.

Proximate composition of meat and skin from raw and cooked parts of 48 ten-week old broiler-fryer class chickens separated into serving pieces were obtained under contract research at Lafayette, Indiana.

B. Food Properties Related to Quality and Consumer Use

1. Chicken. Data were obtained in contract research at Lafayette, Indiana, on (1) the weight of parts from 312 ten-week old broiler-fryer class chickens separated into serving pieces by three different methods; (2) the yield of meat, skin, and bone and tendon from 10 paired raw and cooked anatomical parts of 48 chickens cut by one of the methods. All birds were of the same breed, sex, and age, and received the same ration. The data are being used to revise the Food Buying Guide for Type A School Lunches.

The effects of processing treatment of chicken, such as the use of chemicals in the chill tanks, on drip losses during household handling, cooked meat yield and eating quality are being investigated in cooperation with the Market Quality Research Division, AMS. Freshly killed fryer chickens soaked in (1) water, (2) sodium chloride solution, and (3) a phosphate solution were used in the cooking tests. Other samples will be cooked and evaluated after freezer storage for 6 months.

2. Turkey. Changes in muscle structure, fat and moisture content, tenderness, juiciness, and flavor induced by different heating times, oven temperatures, and degrees of doneness used in roasting and braising are being studied for boneless turkey roasts and whole turkeys.
3. Prepared Foods. Preparation time, quality, and proximate composition were determined for home prepared or purchased canned or frozen chicken and turkey products, including fricassee chicken, chow mein, braised and fried chicken, turkey slices and sandwiches, and turkey and chicken pies and dinners. A technical report of this research is being prepared.
4. Dried Eggs. Research on the use of dried eggs was conducted for application to the school lunch and food distribution programs. Dried whole egg solids from five processors prepared by the newer production methods, including pasteurization, stabilization, drying with indirect heat and gas packing, were used successfully in baked scrambled eggs, custard and yellow cake. Dried egg samples from all processors maintained their initial quality up to 13 months when stored at 40° F. Deterioration at 75° F. was more rapid. After 13 months' storage, samples from only four processors made acceptable yellow cake and from three processors made acceptable scrambled eggs.

Heat penetration during baking of 24 different food combinations in which dried egg was used as an ingredient was determined to indicate the lethal value of the total heating process. Baked foods reaching a temperature of 160° F. or higher in the slowest heating region can be considered safe from any Salmonella organisms present in the food ingredients.

When eggs, inoculated with Salmonella softenberg 775W to a cell concentration of 10,000 per ml., were scrambled to a dry state of doneness in a 10-inch fry pan on top of the range, 2-egg and 6-egg batches were without viable organisms after cooking. The products were not safe when higher concentrations of the microorganisms or larger quantities of egg were used.

C. Food Economics and Diet Appraisal

1. Food Consumption and Dietary Levels. Information on the nutritive value of the food consumption of households based on the 1955 survey data has been summarized in Report No. 16 of the 1955 Household Food Consumption Survey series. Average family food supplies for a week in 1955 were sufficient to provide more than the National

Research Council's recommended allowances for calories and eight nutrients for which values were calculated. However, many households (48 percent) had diets that did not fully meet the allowances in one or more nutrients. Other analyses of survey data show the relation of family size, the education of the homemaker, and of income to the food consumption of households. Because of interest in information on quantities of foods used by high consumers as well as average consumers estimates were made for some 60 food items of the ninth decile--the figure dividing the highest 10 percent of the consumers from the lowest 90 percent. For poultry, the amount consumed per person in "high consumption" households was nearly 3 times as much as in "average consumption" households.

Two surveys were conducted cooperatively with the Marketing Research Division, Economic Research Service, in Detroit, Michigan, and Fayette County, Pennsylvania, to provide evidence on the extent to which food consumption is increased and diets improved as a result of the Food Stamp Program.

A report of the food consumption and dietary levels of a group of older, low-income households in Rochester, New York, is in preparation.

Work is being undertaken on food consumption and nutritive content of diets of individuals. A systematic review and summarization of quantities of food consumed is being made through a cooperative agreement with the Minnesota Agricultural Experiment Station. A similar review of the nutritive content of the diets of individuals is being made by Washington staff.

The nutrient content of the per capita food supply, calculated each year, using data on retail weight quantities of food as developed by the Economic Research Service, provides the only source information of year-to-year changes from 1909 to date.

2. Food Management Practices. Information on the kinds, amount, and nutritive value of foods used and discarded in households has been obtained in a series of small studies. Results will help to evaluate survey data on household food consumption.

A report on household practices in handling and storing of frozen food has been prepared, based on surveys in Baltimore, Maryland, and Indianapolis, Indiana. Households provided information on the length of time frozen food was held in home storage, and the temperature of the compartment in which frozen food was being held at the time of the interview.

3. Development of Food Budgets and Other Basic Data for Food and Nutrition Programs. An important aspect of nutrition research is the interpretation and application of research findings to practical problems of food selection in relation to health. An ongoing program of work includes assembling and interpreting available information on nutritional needs, food consumption, and nutritional value of foods for use by nutritionists, teachers, health workers, and other leaders concerned with nutrition education programs.

A technical report explaining the development of the food budgets, "Family Food Plans and Food Costs," has been completed and is in press. Another in the series of popular publications on food management has been prepared, "Food for the Young Couple." A publication "Family Food Budgeting...for good meals and good nutrition," designed to help families of all sizes is also being prepared.

Regular pricing of family low-cost, moderate-cost, and liberal food plans is published in Family Economics Review on a quarterly basis for the U. S. average and on an annual basis for the regions and the low-cost food plan for the South. Each plan gives suggested quantities of food that will meet nutritional needs for each of 17 age and sex groups and for women during pregnancy and lactation so that household or population totals may be obtained.

Nutrition Committee News, a bimonthly periodical prepared for members of State nutrition committees and other workers in nutrition education provides a channel for disseminating pertinent information and for reporting nutrition education activities. A Nutrition Education Conference sponsored jointly by USDA through its Nutrition Programs Service and by the Interagency Committee on Nutrition Education was held in Washington, D. C., January 29-31, 1962.

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VI. MARKETING SERVICE AND EDUCATION

MARKETING SERVICE WORK BY STATE DEPARTMENTS OF AGRICULTURE
Matching Fund Programs, AMS

The objective of matching fund marketing service programs is to assist producers and marketing agencies in finding answers to their marketing problems through the application of research findings and improved marketing practices. Programs are being conducted in 43 States under the authorization of the Agricultural Marketing Act of 1946. The matching fund program in the States includes four broad fields, namely: (1) Improving or maintaining the quality of farm products; (2) expanding market outlets; (3) increasing marketing efficiency; and (4) collecting and disseminating new and improved marketing data.

The program is carried on by the States with financial support from the Agricultural Marketing Service on approved projects and is administered by a small staff office in the Agricultural Marketing Service. For more information see "Marketing Service Programs," a digest of activities by States, published annually for each year ending September 30, by the Agricultural Marketing Service.

1. Objectives of the Program for Poultry and Eggs

This cooperative work is designed to help people solve marketing problems within the broad fields of work cited above. For poultry and eggs, some of the problems to which this work is directed include determining (1) the most effective quality control and grading programs; (2) the improvements needed in assembling, grading, packaging, refrigerating, transporting and retail display and merchandising to reduce marketing costs and give the product greater consumer appeal; (3) the most efficient facility design, plant layout, and packaging and processing methods for a particular marketing operation; and (4) additions and improvements needed in State and local data on supplies, prices, and movement of the commodities concerned.

2. How the Program is Carried Out

Programs of this type are carried on under projects initiated by the States and submitted to the Agricultural Marketing Service for consideration and approval. If a project is approved, up to one-half of the cost is financed from the appropriation to AMS for "Payments to States and Possessions." Projects are reviewed annually to determine the results being achieved and the need and justification for continued support with matching funds. The program places emphasis on personal contact with producers and marketing agencies in assisting them in finding solutions to their problems.

Considerable emphasis is given in the program to helping producers and local marketing agencies in determining causes of quality losses and in correcting them; also in establishing marketing arrangements between producers and buyers which will facilitate quality maintenance and provide consumers with acceptable products. In this connection, an important objective is to shorten the distribution pattern in the sense of reducing the number of handlings and the time required for the product to reach the consumer.

3. Activities, Accomplishments, and New Developments

Twenty-three States conducted service programs on quality problems in the marketing of poultry and eggs. Twenty-seven had programs in expanding outlets. Sixteen carried on programs on increasing marketing efficiency. Programs to provide current basic data needed in making marketing decisions relating to poultry and eggs were conducted by 14 States.

The following examples of State work will illustrate in more detail the content and procedure of the program in action:

In Arkansas producers and packers of eggs were assisted and advised on supply and demand, proper grading, cleaning, transporting, and storage of eggs to maintain quality. In one instance, a large egg producer-packer confronted with a serious problem of yolk mottling and discoloration was helped, through the laboratory facilities of the Department, in finding the feed ingredient responsible for the inferior quality.

It is anticipated that a series of basic tests used in conjunction with a pilot egg quality program in Kansas to help egg producers meet military requirements will be adopted by all military installations in Kansas as well as State institutions and consumer channels. The basic tests include: (1) Farm breakout using Haugh method for measuring albumen height of eggs, (2) destination breakout, and (3) 10-day breakout to indicate quality.

Several years ago, before the egg quality improvement program was initiated in Alabama, local eggs were of such low quality that dealers were reluctant to handle them. Reports of Egg Law enforcement inspectors of the Department of Agriculture and Industries indicate that approximately 40 percent fewer Alabama eggs were suspended from sale in the State's retail markets compared with a year earlier.

As an outgrowth of activities under the marketing service egg program in New York, a 22-unit supermarket chain inaugurated a grower-distributor program under which locally produced eggs, handled in accordance with requirements of the Empire State Trademark, are bringing premium prices and are the sole source of the chain's egg supply.

California and Colorado carried on intensive programs designed to promote turkey as a year-round food item. These States are working closely with producers, processors, and retail outlets to strengthen relationships of the various segments of the turkey industry and in encouraging better packaging, labeling, and merchandising of turkeys.

Activities of the North Carolina Department of Agriculture designed to expand outlets for shell eggs resulted in the development of a new idea for using eggs. In addition to the Cackleburger, using two eggs and a meat or other filler, recipes were developed for a Cackleloaf, cackleberry pie, and several other new egg dishes. The portfolio of recipes has been submitted to the Poultry and Egg National Board Food Testing Service for evaluation and improvement.

Assistance provided an egg producer-packer by the New York Department of Agriculture in improved handling, work simplification, and installation of automatic sizing and flash candling equipment, resulted in a demand for more eggs than his present 20,000-bird flock can produce.

Under its project to provide needed marketing information for the poultry industry in Florida, the department prepared and released a monthly publication entitled "The Candled Fax," which provides poultrymen with number of layers and young chickens on egg producing farms by areas and other pertinent and current economic information.

4. Future Needs and Plans

The requests for matching funds to work toward the solution of local problems largely reflect local needs. The scope and direction of the work to date has been determined within the framework of the objectives aimed at solving problems within the four major fields of work set forth at the beginning of this statement.

POULTRY STATISTICS PROGRAM
Agricultural Estimates Division, ERS

The purpose of the statistical and other reporting services for agricultural commodities of the Department of Agriculture is to provide accurate, timely, unbiased facts for use in appraising the situation and in making current and long range plans. Historically the statistical reporting service was started over 100 years ago to meet the need expressed by farmers to know as much about crop, livestock, and poultry supplies as the people to whom they are sold. Today this type of information is widely used by farmers, processors, distributors, lending agencies, local, State, and Federal Government agencies and other agricultural interests. With the exception of the Bureau of the Census in the Department of Commerce, which takes a census of agriculture every 5 years, no Governmental agency outside the Department of Agriculture provides any considerable body of official statistics pertaining to agriculture.

The reporting and statistical services include for a wide range of crop, livestock and poultry commodities, current national and State estimates of acreage, inventories, production, slaughter, prices received and paid by producers, value of production and sales and related information. This service work is cooperative and depends to a large degree on the voluntary reporting of information by farmers and by the business men who deal with farmers. These public spirited individuals cooperate with the Department in pooling their information for the common good.

The organizational structure of the Statistical Reporting Service consists of the Agricultural Estimates Division, Field Operations Division, the Crop Reporting Board, and Standards and Research Division. Within AED are the following branches: Livestock and Poultry, Dairy, Field Crops, Fruit and Vegetables and Agricultural Prices. FOD consists of 43 State statistical offices and the Survey Operations Group. The following branches are located in the SRD: Data Processing, Research and Development, Special Surveys and Statistical Clearance. For more information see "Major Statistical Series of the USDA, Volumes 1 and 8, Agricultural Handbook No. 118."

1. Objective of the Program for Poultry and Eggs

The aim of this reporting service is to make estimates by States and for the United States on chicks and poults hatched, broiler placements, chicken and turkey inventory numbers, numbers raised, number of layers and eggs produced, prices received by producers, poultry slaughtered, production of egg products and related statistics, and to issue timely reports on current and prospective supplies for the benefit of producers, processors, distributors, consumers, and the general public. This involves collecting, compiling, and analyzing data from many sources, such as individual producers, processors, handlers, and cooperatives, as well as State and Federal Regulatory agencies.

2. Procedure for Conducting the Program

Most of the basic information is collected, analyzed, and recommended estimates are prepared in the field offices by the State Statisticians. These estimates are reviewed by the Crop Reporting Board and the official estimates adopted. The Board issues releases showing the estimates by States and regions, and in turn the State Statistician issues reports which include supplemental information and details of local interest. In a substantial number of States, an agency, such as the State Department of Agriculture, or the College of Agriculture, cooperates with the U. S. Department in maintaining a joint statistical service for agriculture under the direction of the State Agricultural Statistician. In these States local area and county statistics and other special reports are prepared and published as a part of the State program supplementing the basic Federal program, which is concerned primarily with State and National estimates.

3. Activities, Accomplishments, and New Developments

The established series of reports under this program were continued during the year and some of the reporting programs were expanded. Considerable attention has been given to modifying procedures in order to better meet the growing needs for statistical reports, and to keep up with the changes that are under way. The demands by farmers, industry groups, government agencies and others for more frequent, more comprehensive, more detailed, and more precise reports have continued. Factors affecting the work are the dynamic changes that characterize the poultry industry including increased specialization and commercialization and the declining importance of side line production.

During the year continuing emphasis was placed on improving the statistical reports. Improved stratification procedures, developed in connection with special work in 7 States on improving egg

production estimates, were adopted in several other States and cross-State movement data on broiler-type chicks were improved. The Georgia field office, in cooperation with the Georgia Department of Agriculture, inaugurated an expanded chicken and egg survey. Monthly estimates of each of three segments (1) market egg flocks, (2) hatching egg flocks and (3) farm flocks have been published in Georgia since May 1962. Projects were completed or are being planned in Alabama, Florida, Arkansas, Oklahoma, and New Mexico, where large flocks are enumerated monthly and estimates for the rest of the universe obtained by sample. A survey on cross-State movement of egg-type chicks was made at the end of the year.

4. Future Plans and Needs

Continuing effort will be made to keep up with the changes under way in the Poultry industry. Increasing requests from industry, governmental agencies and other agricultural interests have been made for more comprehensive statistical data. To do this surveys would be needed to measure year-to-year changes in the number of egg producers by size group strata; the improved sampling procedures by size groups being developed would need to be implemented in additional States; the weekly broiler placement report would need to be expanded to include 8 States in addition to the 22 now included; cross-State movement data for egg-type chicks would need to be collected monthly, and egg-type chick placements would need to be collected weekly in several States. A survey needs to be made to determine quantities and kinds of feed fed to poultry. Representatives of the Poultry Industry have urged that series of mid-month prices be published for market eggs, in addition to the present all egg price series which includes prices for hatching eggs and eggs retailed by farmers. Both hatching eggs and retail eggs bring relatively higher prices than regular market eggs. Differences between States in the relative importance of these higher-priced egg categories have resulted in significant differences in levels of State average prices for all eggs.

5. Publications

The following reports which include data on chickens, eggs and turkeys are issued regularly by the Crop Reporting Board, U. S. Department of Agriculture, Washington, D. C. Excerpts from most of the reports, with supplementary State and local material are issued by the State Agricultural Statisticians' offices in each State.

<u>Report</u>	<u>Approximate release date</u>
Intentions to raise turkeys, by States	January 16
Intended purchases of baby chicks, by geographic areas	February 10
Chickens and turkeys on farms January 1 by classes, value per head and total value, by States	February 13
Revisions of monthly egg production, by States	February 28
Annual summary of weekly broiler chicks placed, 22 States	March 6
Production, disposition, and value of sales of turkeys, by States	March 30
Commercial broiler production, price and value, by States	April 24
Estimates of chickens raised, by States	April 24
Production, disposition, and value of sales of chickens and eggs, by States	April 24
Intentions to raise chickens, by States	July 24
Estimates of turkeys raised, by States	August 28
Composition of farm flocks on October 1, i.e. pullets of laying age, pullets not of laying age, other chickens and hens, by geographic regions	October 10
Intentions to keep turkey breeder hens, 15 States	October 23
Poultry slaughtered under Federal Inspection and poultry used in canning and other processed foods	1st of each month
Number of layers, rate of lay and total egg production by States	10th of each month
Number of pullets not of laying age and potential layers on farms first of August through first of January, by months, by geographic areas	10th of each month, Aug. through Jan.

Leading breeder report on pullet chicks placed for broiler hatchery supply flocks	15th of each month
Commercial hatchery production of chicks, by States	16th of each month
Commercial hatchery production of turkey poults, by geographic regions	16th of each month
Turkeys and chickens tested by official State agencies	17th of each month
Production of liquid, frozen and dried eggs	25th of each month
Average prices received for farm chickens, commercial broilers and eggs, by States	30th of each month
Average prices paid by poultrymen for poultry feed and for chicks, feed-price ratios, by States	30th of each month
Chicks placed for broiler production and eggs set in 22 States	Every Wednesday
Turkey eggs set and poults hatched in important States	Every Thursday



